TOP DISTROS!
The best distros for Windows escapees

LINUX VOICE
We dig up the old team and Nick Veitch

3D PRINTING
Get started with resin and filament

LINUX FORMAT

The #1 open source mag

ESCAPE WINDOWS!
Save all your old PCs and install Linux Mint

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- Get making with the Pi
- Hack your networks
- Start learning to code

100 pages of Linux tricks, tips & more!

PLUS: HOW TO

- » Photo-edit like a pro using GIMP 3
- » Power AI loads over networked systems
- » Run Linux on your own supercomputer

BUILD A SERVER
Run all your services at home on Debian

RUST ON THE PI
Get developing your memory-safe apps

REVIVE THE BBS
How classic bulletin boards can live on

LXF July 2025
FUTURE

8jw0QGqdRsHpplQFjEgfZwb

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25 years of Linux Format

MEET THE TEAM

Just revolutioning

What an amazing 25 years! Since May 2000, *Linux Format* has been entertaining, informing and educating anyone who would listen about the world of free and open source software and the Linux kernel to this final issue. Over the years, *Linux Format* has been privileged to have not just the leading big brains at the forefront of development contribute to the magazine, but *the* leading big brains like Linus Torvalds himself, Richard Stallman, who created GNU and the FSF, Mark 'Ubuntu' Shuttleworth multiple times, and the sadly deceased creator of Debian, Ian Murdock. Whom the original editor Nick Veitch talks about interviewing over the page.

I feel truly privileged to have sat in the editor's seat for so many years – a unique experience and an extraordinarily rewarding job. I have to offer my unfettered admiration and thanks to the previous editors (Nick, Paul Hudson and Graham Morrison) and the original staff (such as Effy, Mike Saunders, Andrew Gregory and Neil Bothwick), alongside an army of incredibly talented contributors who gave up their precious time and hard-won expertise for the pittance our Future editorial budgets would pay. While, of course, thanking you, our dear readers, for sticking with us over so many years and typos.

Since **LXF** launched, the kernel (and open source) has gone from a geek curiosity to tech-giant colossus; powering the top 500 supercomputers, underpinning and powering the modern web, defining the smartphone, the smart home, digital streaming, generative AI, SteamOS gaming, and even flying copters on Mars. It doesn't get any more exciting than this – the revolution Nick asked you to join 25 years ago is still going strong and doesn't look like it's ever going to stop!

Neil

Neil Mohr Editor

Back issues!
Digital and print: see page 64

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GET INSIDE OPEN AI

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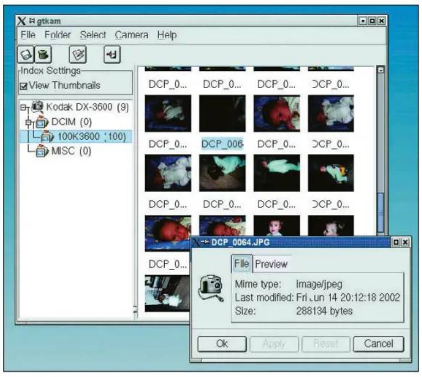
gtkam
File Folder Select Camera Help
Index Settings
View Thumbnails
Kodak DX-3600 (9)
DCIM (0)
100K3600 (100)
MISC (0)
DCP_0064.JPG
File Preview
OK
Apply
Reset
Cancel

Mime type: image/jpeg
Last modified: Fri Jun 14 20:12:18 2002
Size: 288134 bytes

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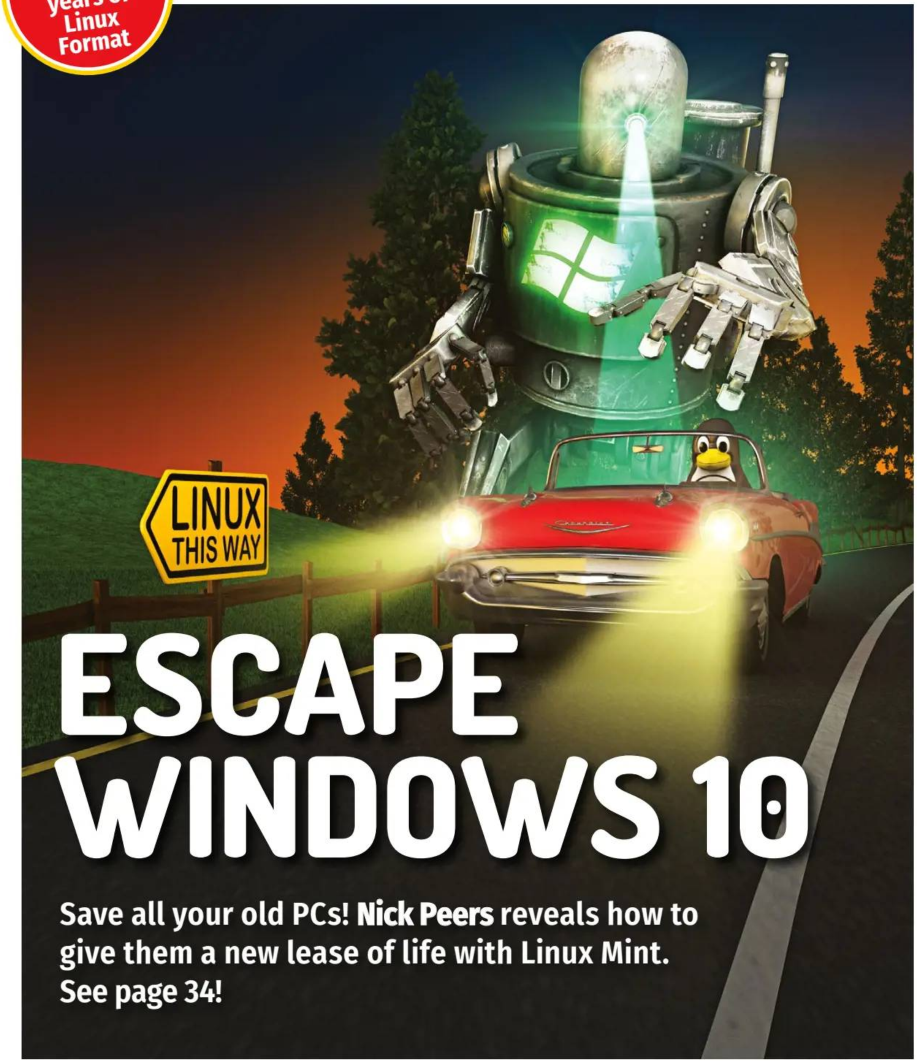
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CREDIT: Magictorch

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CREDIT: Magictorch

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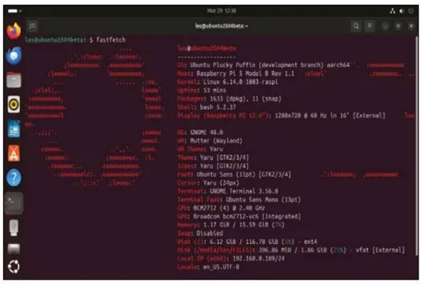

```
les@ubuntu2504beta:~$ fastfetch
                                   les@ubuntu2504beta
                                   ------------------
                                   OS: Ubuntu Plucky Puffin (development branch) aarch64
                                   Host: Raspberry Pi 5 Model B Rev 1.1
                                   Kernel: Linux 6.14.0-1003-raspi
                                   Uptime: 53 mins
                                   Packages: 1633 (dpkg), 11 (snap)
                                   Shell: bash 5.2.37
                                   Display (Raspberry Pi 13.3"): 1280x720 @ 60 Hz in 16" [External]

                                   DE: GNOME 48.0
                                   WM: Mutter (Wayland)
                                   WM Theme: Yaru
                                   Theme: Yaru [GTK2/3/4]
                                   Icons: Yaru [GTK2/3/4]
                                   Font: Ubuntu Sans (11pt) [GTK2/3/4]
                                   Cursor: Yaru (24px)
                                   Terminal: GNOME Terminal 3.56.0
                                   Terminal Font: Ubuntu Sans Mono (13pt)
                                   CPU: BCM2712 (4) @ 2.40 GHz
                                   GPU: Broadcom bcm2712-vc6 [Integrated]
                                   Memory: 1.17 GiB / 15.59 GiB (7%)
                                   Swap: Disabled
                                   Disk (/): 6.12 GiB / 116.78 GiB (5%) - ext4
                                   Disk (/media/les/FILES): 396.86 MiB / 1.86 GiB (21%) - vfat [External]
                                   Local IP (eth0): 192.168.0.189/24
                                   Locale: en_US.UTF-8
```

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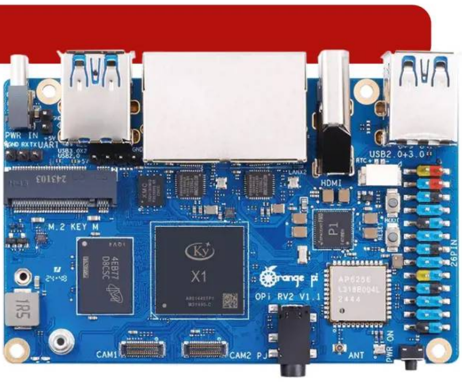

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Electrum Testnet 4.5.8 - test wallet [standard]
File
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View
Tools
Help
History
Send
Receive
Channels

1 transactions

Date	Description	Amount	Balance
Not Verified [1. sat/vB]		+0.38625	0.38625

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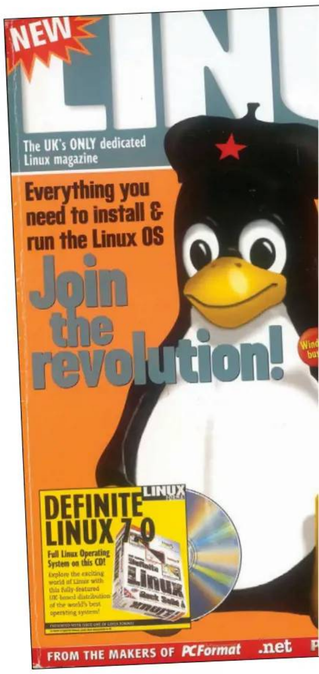
Join the revolution!

The battle cry from the original **LXF001** still rings true. Look back with some of the original staff at how *Linux Format* launched, managed to keep going and racked up 25 years.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Join the revolution!
DEFINITE LINUX 7.0
Full Linux Operating System on this CD!
FROM THE MAKERS OF PC Format .net

NICK VEITCH

Editor 2000–2008

LXF001 to LXF142

When I first started *Linux Format,* I had two central ideas. I also had two desks, one computer and an amazing six weeks until the first deadline… But back to the ideas.

The first was that it should be a proper '*Format*' magazine – one that really understood what the readers wanted and delivered entertainment and information in good measure, as well as a coverdisc full of useful things.

The second was that it should take more leads from the vibrant community of open source. In some respects, the magazine still had to be a gatekeeper, or at least a filter of ideas, but we (two more staff joined after the first week) really felt like we were curating a magazine that let the readers and the wider open source community determine what was important and what we should be covering. The very first issue had a letters section – possible because we ruthlessly canvassed online Linux communities for ideas and got them to mail us.

> "We really felt like we were curating a magazine that let the readers and the wider open source community determine what was important"

I guess an early example of how this played out was the *Distrowatch* section. I wanted to track and inform people about the latest releases in the incredibly fast-moving space of Linux distros. There were no defined release schedules in those days, and there were many quirky takes on what a distro should be and how it should work, so it seemed like a good thing to cover. After the first column went out, we were contacted by a reader who had independently had the same idea and had created a website, also called Distrowatch! He'd done such a good job on it that we immediately gained a regular and long-standing contributor.

I'm pretty proud of what we managed to create with *Linux Format,* a magazine few people thought was more than a fad. Because of its deep ties with the community, it became a focal point of what was actually going on in the world of open source, and made familiar names (and sometimes faces) of the real people doing exciting, innovative and occasionally ridiculous things with our favourite OS. Thanks for sticking with us on the journey.

I have many, many memories from my time working on the magazine, but several in particular stand out.

The original internal shortcode for the magazine was **LF0**, but I thought there should be an X in it, so I managed to change it by simply using **LXF** for everything until people stopped bothering to correct it.

In the early days, Richard Drummond used to attempt to compile a new kernel pretty much every night. There were always things to tune or fiddle with, but a build would take hours and hours, so after half an hour of guessing what the options in `make menuconfig` might really mean, he set off a build and went home, turning up the next day to discover he had a great kernel for graphics performance but had failed to enable the keyboard driver… Richard is one (maybe the only) regular member of staff to have actually contributed to the Linux kernel and had his code accepted.

One day in 2001, work on the magazine had to stop temporarily because maggots rained down on the desks from the ceiling (cause: dead wildlife in the attic). Really. Hundreds of them. It was just after lunch, too.

In 2007, some of the team took a short five-minute break from creating the best Linux magazine to watch a comet (thanks *Kstars* and *Stellarium)!* It was Comet McNaught (C/2006 P1), and it was (just about) visible in the daytime – but only from some particular windows in the Future sweatshops. We temporarily invaded the desks of some stitching magazine to stare out the window. Thanks for putting up with us.

Linux Format was the first magazine to include a bootable Linux DVD. In fact, we are pretty sure we might have been the first people to create a Linux bootable DVD, judging by the number of distro people who asked us how we did it. To top that, we also made

25 years of Linux Format

www.linuxformat.co.uk

25 pages of Tutorials, How-tos and tips

Everything from Apache to Zip drives explained this issue!

Apple Networking

Fool Macs into thinking your Linux box is one of them!

Open Source?

What does it all mean, and is it a Good Thing?

Which distro?

All the popular Linux flavours rounded up and rated.

BEGINNERS START HERE!

Full Linux Distribution on the CD, plus an exhaustive ten page guide to installing your new OS.

LXF01 £4.99

MAY 2000

WELCOME intro

WELCOME

You hold in your hands the very first issue of the very first UK newsstand magazine dedicated exclusively to the Linux operating system. The Linux community has been without such a magazine for too long, so we're here to put things right!

As you can see from our aims listed here, we exist not only for current Linux users, but also to help welcome converts into the fold. To this end we have a special beginners' guide in this issue, starting on page 48, and a full Linux distribution on the CD. I hope veteran Linux users won't be too upset about the space this takes up – we all have to make a start somewhere, after all!

The mainstay of this magazine will be its features, which we hope will entertain and inspire you, the reviews and roundups to guide you through the ever growing range of Linux software and our tutorial section, which should provide a handy guide for Linux advocates of all degrees of experience.

We want to create the best magazine we can for all our readers, and all serious suggestions will be considered, so tell us what you'd like to see and we'll do our best to give it to you! There are plenty of contact details here so you can easily get in touch with the relevant people. Go on, don't be shy – we all know Linux users are a vocal bunch, so let's put your opinions to some good use!

Nick

Nick Veitch
Editor

Chris Crookes
Art Editor
He does the design and pictures. Don't worry, he can't hurt you.

Richard Drummond
Staff Writer
His words of wisdom are scattered liberally within.

The aims of this magazine...

Linux Format is a magazine dedicated to Linux and the Open Source community. The aims of this magazine are quite simple.

- To help our readers get more out of their Linux experience, through our tutorials, features and advice pages.
- To provide Linux Users with accurate and unbiased information.
- To promote Linux and the Open Source movement.

Contact us

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Phone: 01225 442244 Fax: 01225 732295

MAY 2000 LINUX FORMAT 5

The infamous Ian Murdock interview that had Slashdot melting down the TuxRadar servers.

the first covermounted full-size DVD (using all the space, not just the first 2GB) by some judicious use of very fast machines and some hacked-together *Bash* pipelines that chunked packets in real time to avoid the very real 32-bit file size limitation.

For a while, *Linux Format* lived in offices that had been a Co-op bank. The DVDs were mastered in a room that still looked like (because it was; it was also a health and safety hazard) a giant walk-in safe, complete with spinning wheels to close the 8-inch steel door.

One time after various things went wrong and all contingencies were used up, a four-page hole appeared in the magazine flatplan with two days until the print slot. I left the office at 11pm claiming that unless some magic pixies turned up to do the work while I slept, everyone was doomed. The next morning, some magic pixies had emailed in a four-page security feature (it was actually a swap from *Maximum Linux* – a short-lived sister magazine to **LXF** based in California that had re-used about 30 pages of previous **LXF** content and thought they owed us something in exchange). It just needed some tweaking and everyone was saved! And from that day on, I believed in the power of magic pixies.

I once worked out a problem for an Arduino article in a dream. The dream had monkeys in it who actually solved the problem, but the printed article failed to give them credit. Sorry imaginary monkeys, but the world benefited from your greatness anyhow.

Writing *HotPicks* was always a major undertaking. In the early days, finding interesting projects to write about wasn't hard, but getting them to build certainly was. Around 50 hopefuls would effectively whittle themselves down to the 10-12 we would write about.

Future Publishing's internal LDAP-based *People Finder* tool came about over an argument with the IT department over whether a workable directory app could be developed with open source tools in a single lunchtime. It could (though we did sometimes take quite long lunches).

Linux Format used to run its own web server, because the team was affronted and afraid of the names they would be called if they used the Windows servers the rest of Future Publishing used. This was an

Four Linux magazine editors walk into a pub... Beer was drunk and food was eaten!

»

Oh Lord, who's left Dr Jonni unattended with a pint of Bath's finest Gem IPA?

Issues **329 + SPECIALS**
Pages **32,000+**
Words **20,000,000+**
CDs/DVDs **295+**
Editors **4** Art eds **4**
Prod eds **5** Disc eds **5**
Contributors **227+**
Production babies **7**
Breakdowns **4**
Rival startups **1**

interesting and educational experience (don't mention the time it got rooted by East European criminals!) but it did mean we were a law unto ourselves and could operate our PDF archive (yes, it's still running the same old PHP) for subscribers.

Linux Format once had the largest tower of vending-machine plastic cups and the largest rubber-band ball in all of Future Publishing – at the same time. The former was eventually demolished by cleaners as a health-hazard and the latter had to be decommissioned after magazines downstairs complained about us bouncing it. Yes, we know plastic cups are bad – it was actually a protest about the removal of our filter coffee machines!

For the issue 96 feature on *Scribus*, the entire feature was designed and laid out in *Scribus* itself (another **LXF** first). Because of the direct PDF to plate technology we used to print the magazine, nobody was actually sure whether it would work or not, so it was some relief to get the magazine back and find out the pages weren't blank or full of PostScript errors.

Linux Format had two unofficial-official games of choice – *Unreal Tournament* (curse you, Hudzilla) and the less resource-hungry *Crack Attack* (curse you again, Hudzilla).

To Nick's credit, the original content lineup of Roundup, HotPicks, Answers and the coverdisc was so strong, it ran to the bitter end. OK, apart from the coverdisc…

I bought the very great but quite reclusive (and since 2023, sadly missed) Bram Moolenaar his first ever pint of Guinness.

In the licensed Russian version of **LXF**, *HotPicks* was one or two pages longer. The translators told us this was because they had to add extra text to explain the puns, jokes and obscure film and lyrical references…

Legendary art editor Chris Crookes was the magazine's most vocal advocate for featuring Tux everywhere. The rest of us felt that having to include a rendered penguin in everything was restrictive and didn't distinguish us visually from other (inferior) Linux titles. But the idea grew on us. Eventually.

In 2007, we had an interview scheduled with Ian Murdock, who was working for the Linux Foundation and appearing at a Linux show. On the day of the interview, the PR people cancelled it without explaining why and said he wouldn't be coming to the show. But we had seen him there… Suspicious, and as our **LXF** people on the ground had a freelance photographer already booked and ready, they set off to Murdock's hotel, where he did pop up in the lobby to give us quite a sensational tale. "I can see this all over Slashdot as I speak the words," he said, and he was right. When we published the interview online, our server couldn't keep up with the demand and pretty much melted.

MAILSERVER

Share your opinions, right wrongs and demand justice by writing in to Linux Format. Drop us a line at: Linux Format, Future Publishing, 30 Monmouth Street, Bath BA1 2BW or email linuxformat@futurenet.co.uk

ANSWERS

If you are really stuck, why not write in? Resident gurus Dave Co
Richard Drummond will answer even your most complicated prob

REVIEWS | Hot Pics

HOT PICKS

Every issue Richard Drummond will be rounding up the hottest new software that has come to our attention. If you can th
something we should include for next issue, email us at linuxformat@futurenet.co.uk

wmtheme

Function: Desktop configuration Version: 0.0.4
Website: wmtheme.snowblind.org Packages: deb, tgz

Grip

Function: CD player/ripper

CD PAGES | coverdisc

LINUX Format Coverdisc

This month's CD features a full Linux distribution, Definite Linux 7.0, but please read the information below before you install!

WHAT DO YOU WANT ON THE CD?

This is your chance to tell us what you want on the CD. Do you want updates, patches, latest software, HTML resources, PDF files, source, ridiculous pictures of the LXF team in embarrassing poses?

IMPORTANT NOTICE

PAUL 'HUDZILLA' HUDSON

Editor, 2008–2011

LXF041 to LXF143

Honestly, I can't believe this is **LXF329**. 329! That number alone is testament to how much love there is out there in the community, and how much people enjoy sharing their excitement around open source software.

I first started writing for *Linux Format* almost 300 issues ago, mostly because I was annoyed that there was no regular tutorial on PHP. Over the years that I worked there, I got to witness up close the introduction of x86-64, the then-breakthrough *Xen* hypervisor, and the wobbly windows fad when *Compiz* was first released. And I also played far, far too many games of *Crack Attack*. It was literally my job to poke new things with a stick and see what they could do, and I'm very grateful for all the opportunities it gave me.

> "I've had the great privilege of seeing open source make a significant impact on other software developers"

Today I still run Linux on all my servers, and wouldn't have it any other way. I also still release almost all my work as open source, and again can't imagine doing anything different – open source is baked deep into the way I think and the way I work, and I've had the great privilege of seeing it make a significant impact on other software developers.

So, goodbye to *Linux Format,* and farewell to **LXF** Towers. You had a fantastic run, and will be remembered for many years to come!

Google Android » The Linux Quiz » LTSP
LXFDVD
Foresight Linux 2.0
PLUS: PC-BSD 1.5
LINUX FORMAT
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CLI Phrasebook
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www.TuxRadar.com

GRAHAM MORRISON

Editor, 2011–2013

LXF061 to LXF178

Where to start? Not knowing who Richard Stallman was at my interview?

I remember commissioning a cover feature on smart homes only to find on press day it was a disaster. After an editorial panic, we had a collection of articles on penetration testing. A moment of collective genius later and "Learn to Hack" was written in big, bold letters across the cover. When the magazine went on sale, our 'irresponsible' headline reportedly led to the issue being removed from some shelves and became one of our biggest ever selling issues!

Then there was the first Raspberry Pi, in 2012. Eben Upton got us early access to a production board for Jonathan Roberts to write about, which he did amazingly in just 48 hours. We were even able to get a perfectly scaled image of the board on the cover (rescaled at the last moment when I got a ruler out against the print proof). The Pi was released on exactly the same day that the issue hit the stores, and that issue of *Linux Format* completely sold out when the release news hit the BBC.

For many years, I was lucky enough to visit Portland, Oregon, in the US, for O'Reilly's Open Source Conference (OSCON). Every time, I'd send Linus an email and politely ask if he'd be interested in an interview. We never received a response – until one July evening in 2012. My phone pinged, and it was the email we'd never dared to hope for – a reply from Linus saying, "Sure, how about tomorrow?"

We piled into an ancient Honda and headed over to Linus's home, almost causing a disaster when we jammed on the handbrake to stop the car without knowing Linus's wife was behind us and had to make an emergency stop! Fortunately, both Linus and Tove were very forgiving and the subsequent interview is something I'll never forget.

Graham Morrison continues to work with Linux at Canonical, and you can still hear him in podcast form each week on Late Night Linux (**https://latenightlinux.com**).

Roundup: Best beginners' distro
LINUX FORMAT
#1 for Free Software
Fund your dreams
How crowdfunding is transforming the economy of free software
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Renaissance man
Most people today write more than Charles Dickens did in his lifetime
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Packed with Linux advice
OpenSUSE 11.4 Tried & tested
Turn WordPress into a full CMS
Get more from mythTV
Master the ultimate digital TV platform with our guide to all things mythical
Pause, record and rewind live TV
Cut out those annoying ads
Get even more channels
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»

MICHAEL 'MIKEOS' SAUNDERS

Writer & disc editor, 2005–2011

LXF071 to LXF154 (LXF001 writing)

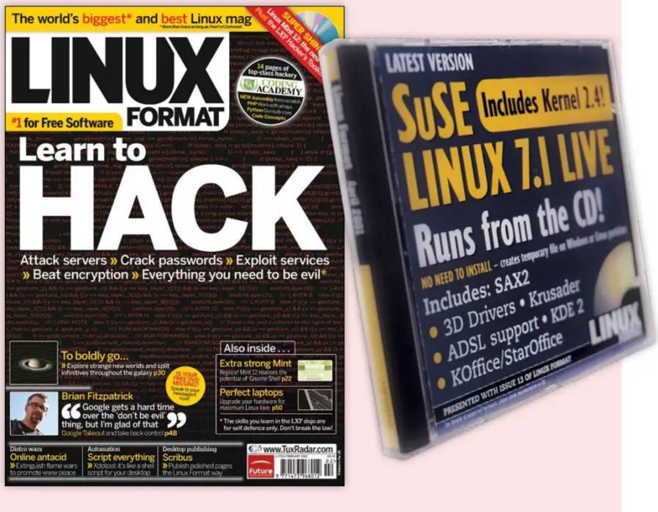
Blimey. Twenty-five years of *Linux Format*. I remember writing the distro roundup for **LXF001**, juggling CDs to install various flavours of Linux on a generic chunky white-box PC with a 233MHz Cyrix processor and 32MB of RAM. Uphill both ways. And we loved it! Most of those distros are long gone, of course – but the temptation to keep trying new variants of the operating system is still there. That reminds me – I haven't checked Distrowatch in the last 20 minutes. Maybe I'm missing something…

Working at *Linux Format* was an awesome time. Back when I was in the office, we were surrounded by more mainstream computer magazine teams who didn't quite understand what we were doing. Yeah, they had heard of Linux, but it was the geeky nerdy thing that didn't have games and proper apps and stuff. Of course, they were totally wrong – we had *XBill!*

One of my tasks at **LXF** was to create the CDs (and later DVDs), doing various bits of black magic to make the discs multi-boot several distros. Then run a script to catalogue all the software I'd selected, generate an ISO, and test, test, test. The most nerve-wracking part was taking the master CDs or DVDs to the courier to be sent to the duplicators. There was no going back then…

Today I'm still in the FOSS world, working in marketing and community outreach at The Document Foundation, the non-profit entity behind *LibreOffice*. Although office suites aren't the sexiest things in the world, tens of millions of people benefit from them and we have a strong sense of mission, so I love being at The Document Foundation.

But yes, farewell *Linux Format* and thanks for all the good times. (Last anecdote: once we were trying some voice recognition software for the mag, and when we said its name, it wrote 'Lion Eggs Format'. Hmm.)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EFRAIN 'EFFY' HERNANDEZ-MENDOZA

Art editor, 2006–2022

LXF073 to LXF295

From 2006, and for 16 incredible years, *Linux Format* was a huge part of my life. As art editor of the leading publication in its field, I had the privilege of working alongside some of the most knowledgeable and passionate minds in the Linux world.

What made it truly special wasn't just the magazine itself, but the people – both behind the scenes and reading every issue. The passion wasn't limited to our team; it radiated from the wider Linux and open source community. Every edition helped deepen those connections, and I was proud to contribute to something that meant so much to so many.

That sense of community is what set *Linux Format* apart as a magazine. Through ongoing interaction with readers and contributors, I witnessed first-hand just how generous, collaborative and insightful the open source world can be. We constantly learned from each other – and grew because of it. (Mint is still my favourite distro, by the way!)

I was probably the least technical person at **LXF** when it came to Linux itself, but that never held me back. Thanks to what I learned from the team and the community as a whole, I found my own way to contribute – translating ideas visually and bringing our editorial voice to life through design.

Fun covers, complex tutorials (yes, I even wrote one) and creating graphics for subscription gifts became my everyday challenges – and I loved every moment of it. I hope, in some way, my work gave something back to the community that gave me so much.

Being art editor of this magazine made me feel part of something elite – something meaningful. And for that, I'll always be grateful.

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ANDREW GREGORY

Prod & deputy editor, 2008–2013

LXF65 to LXF92 & LXF110 to LXF178

Ah, *Linux Format*. There are many memories, though not quite as many as there would be if we hadn't held so many crucial editorial meetings in the beautiful Salamander pub in Bath. I learned the art of magazines from the best, including a senior editor who I won't name but who somehow made a career out of looking at our immaculate magazine covers and 'improving' them by telling us to make certain words bold or yellow (or, innovatively, bold AND yellow).

I remember the challenge of trying to dual boot Mandriva Linux on a Dell Inspiron with a hefty 512MB of RAM, followed by the terror as I had somehow managed to partition over the machine's bootloader. Then switching to Debian, then SUSE, then Ubuntu, then Linux Mint, and most recently to Raspberry Pi OS.

Linux people are interested in things and ideas. Linux enthusiasts always have a hinterland that other geeks often don't, because they've got into Linux as a means to an end. Whether you want to brew beer, explore the night skies, control a model railway or anything else, free software has got your back, and that means there are Linux geeks from all backgrounds. Where most of the internet is a cesspit, the corner of it we looked after at **LXF** was a civilised, courteous, helpful place full of genuinely lovely, interesting people.

Is this the year of Linux on the desktop? Maybe – it depends on how you define desktop. But I can say that this definitely is the year of Linux on the information screens at Heathrow Airport; it's the year of Linux on the scoreboards at Lord's cricket ground, in cars and cocktail machines, and in countless embedded machines that are all around us. There's a huge community of makers tinkering with Raspberry Pi, adding sensors, motors, servos and other devices to their Raspberry Pi machines – and they are all running on Linux.

RHEL 5 » Ian Murdock » GNOME 2.18
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DR JONNI BIDWELL

Technical editor, 2013–2022

LXF184 to LXF295

It was exciting when I first installed Linux on my own PC. I'd used it at university, but now, in mid-2003, I had root. Here was me running Red Hat Linux 8, replete with Nvidia's GeForce and nForce proprietary drivers. I think I even had the 56k modem working. I didn't use Linux for much other than work at the start, but more and more, its claws dug in. Of course, Linux had been around for a dozen years at this point, so by some standards it was mainstream. Very niche standards…

Anyway one day, as I booted Gentoo and did a casual `emerge -pDuv world`, a friend watching the screeds of compiler output exclaimed, "What the heck are you doing?" I realised I had joined the dark side. I don't know at what point USB devices actually automounted or when *MPlayer* would actually inhibit the screensaver, but they seemed like things that bugged me for years. And worse, from reading forums, they were supposed to just work.

> "I didn't use Linux for much other than work at the start, but more and more, its claws dug in"

Today I have all manner of Linux bugbears (currently the Snap daemon inhibiting system shutdown), but none so persistent. We lived through the Flash era. We don't have to edit **XF86Config**, later **xorg.conf**. We have a web that works on all platforms, never mind that for the most part it's a tarpit of ads, tracking and SEO-optimised drivel. We can run Windows games better than Windows can.

It is sad to see **LXF** go, but the golden age of magazines is long over. If I ever update it, check **https://jonni.xyz** to see what I'm up to. And thanks so much for reading! LXF

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Newsdesk

THIS ISSUE: Tactless Torvalds » Steam support to stop? » Nvidia opens up » Fork uplift » Linux love gets larger

KERNEL

Linus's GCC 15 mistake

Linus Torvalds voluntarily took a step back in 2018 after admitting his communication style with other developers was sometimes inappropriate.

CREDIT: Krd, CC BY-SA 4.0,https://commons.wikimedia.org/wiki

Torvalds's fix for GCC 15 reignites debate over his communication style and the kernel's future under his benevolent dictatorship.

Linus Torvalds's discussions surrounding a compatibility issue with GCC 15 has reignited long-standing online debates.

The most recent controversy surrounds the 6.15-rc3 kernel release and implementation of -Wunterminated-string-initialization in GCC 15.

Instead of deferring to existing fixes in the next branch by the likes of kernel developer Kees Cook, Torvalds took it upon himself to patch the code. In doing so, he inadvertently caused some compatibility issues with versions of the GCC compiler system before v15.

Cook criticised the move, particularly as there were existing patches, so Torvalds had created merge conflicts. He also pointed out that in the past Linus has berated maintainers for making similar careless mistakes.

This incident mirrors previous clashes between Torvalds and other developers, which led to him taking some time off in 2018 due to emails that he himself referred to as "unprofessional and uncalled for".

After his apology and self-imposed time off, Torvalds returned to Linux development under a revised code of conduct, implemented by the Linux Foundation. This requires all contributors to deliver criticism constructively and accept criticism mindfully. It's unclear if Torvalds did so in response to Cook's admonition over GCC 15, as he fired back: "I did not *CARE* about coordinating… If you had fixes for it, and they hadn't made it to me, that is 100% on *you*."

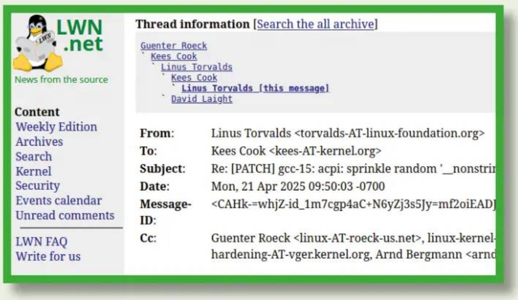
This shifting of blame on to another developer, as well as an ambiguous review process for patches, raises important questions for the long-term maintainability of the kernel.

The situation wasn't helped in early 2025 when kernel developer Hector Martin stepped down as a maintainer, due to what he called a lack of support from Torvalds. The two had previously clashed over the integration of Rust code in the kernel. Martin drew sharp criticism from Torvalds after the Linux head accused him of social media "brigading" over the issue.

The GCC 15 debacle underscores the ongoing stumbling blocks to the kernel workflow. Despite tools like CI/CD and standardised automated testing in modern software, the kernel still relies heavily on manual processes and decisions under Torvalds's benevolent dictatorship.

In late 2024, the lead developer of the bcachefs filesystem, Kent Overstreet, crossed swords with Torvalds over this very issue by advocating for faster release of patches without the laborious public testing process currently in place. Torvalds responded by threatening to remove bcachefs from the mainline kernel.

Looking to the future, it'll be interesting to see how much longer Torvalds takes this leading role in Linux development and how any stepping back or handing over the reins will be managed, though Greg Kroah-Hartman, the stable branch maintainer, remains the primary choice.



Thread information [Search the all archive]

Guenter Roeck
` Kees Cook
  ` Linus Torvalds
    ` Kees Cook
      ` **Linus Torvalds [this message]**
    ` David Laight

From: Linus Torvalds <torvalds-AT-linux-foundation.org>
To: Kees Cook <kees-AT-kernel.org>
Subject: Re: [PATCH] gcc-15: acpi: sprinkle random '__nonstri
Date: Mon, 21 Apr 2025 09:50:03 -0700
Message-ID: <CAHk-=whjZ-id_1m7cgp4aC+N6yZj3s5Jy=mf2oiEAD
Cc: Guenter Roeck <linux-AT-roeck-us.net>, linux-kernel-hardening-AT-vger.kernel.org, Arnd Bergmann <arn

The latest spat between Cook and Torvalds raises important questions concerning the submission and review process for software patches.

GAMING

COCOON
Play Aperture Desk Job

The latest version of SteamOS now supports the Legion Go S trackpad and has better connectivity for DualShock 3 controllers.

SteamOS support issues

Valve widens SteamOS support for other handhelds, while ending legacy Linux Steam client compatibility.

Recent updates to SteamOS have introduced both certain promising upgrades as well as some concerning support challenges for Linux gaming fans.

At the time of writing, the most recent SteamOS preview is version 3.7.5. This includes trackpad support for the Legion Go S, signalling Valve's commitment to support its OS on devices besides the Steam Deck itself.

There were clues to this in late 2024, as noted by outlets like *Linux Format,* when Valve revised its branding guidelines to include a dedicated section for third-party devices.

So far, there are no official plans for a desktop version of SteamOS. The gaming-focused distro Bazzite Linux, which can also be deployed on a variety of handhelds, is compatible with desktop machines.

This is probably just as well, given that Valve has also announced that as of 15th August, Steam will officially end support for Linux distros with a version of glibc older than 2.31. The Steam client will not launch, forcing users to upgrade to continue accessing their games.

Most major Linux distros, such as Ubuntu, Debian and Fedora, already meet these requirements. Users on older systems will either need to upgrade their OS, or install the Flatpak version of the Steam client, which comes with its own libraries.

HARDWARE

Nvidia moves to open source

Nvidia placates community and antitrust investigators.

Historically, Nvidia has had an on-again off-again relationship concerning its support for community-driven projects, especially as it relates to providing open documentation for its hardware.

Yet the tech giant's latest open source strategy has been well received, given that as of Mesa 25.1, Nouveau users will no longer get the old Nouveau OpenGL driver by default. Instead, they'll get Zink+NVK – an OpenGL implementation written on top of Vulkan.

This development addresses years of complaints concerning Nouveau's supposed performance implementations. NVK will now be the default for GPUs from the Turing era onwards. Paired with Zink's OpenGL-on-Vulkan implementation, this will likely deliver significantly better performance, especially on Maxwell, Pascal and Volta architectures.

This move hasn't occurred in isolation. Nvidia recently decided to open source its KAI Scheduler under the Apache 2.0 licence.

Nvidia's blog stated that this was to "foster community collaboration". A more cynical interpretation is that this is in response to antitrust investigations in the US and China.

Since Nvidia became the lead manufacturer of AI chips, its market dominance makes it hard for the company to acquire any new companies without facing yet more antitrust scrutiny.

After acquiring Run:ai in late 2024 for around $700 million, Nvidia announced plans to open source Run:ai's platform, most likely in a bid to appease antitrust investigators.

CREDIT: Valve

OPINION

OFFICE PARTY

Italo Vignoli is one of the founders of LibreOffice and the Document Foundation.

"The end of *Linux Format* is a sign of the operating system's success, not its defeat. In fact, without Linux, the global network infrastructure that allows us to communicate would not exist today, nor would research projects such as those at CERN and NASA that enable humankind to understand where we come from and where we can go.

Today, Linux is also growing on the desktop, despite everything and everyone, and it cannot be otherwise, because its superiority over Windows and even Mac OS – based on a similar kernel – is absolute.

And if we have come this far, part of the credit goes to *Linux Format,* which has informed users and helped to grow the culture of free and open source software.

Unfortunately, this also means that Linux is so widespread and well known that it no longer needs dedicated magazines like *Linux Format.*.

The *LibreOffice* project will continue, sadly without the support of **LXF**, but at this point, a thank you to all the journalists who have worked on it is necessary. If you feel like writing something about *LibreOffice* and the Open Document Format, the pages of our blog are always open. Thank you for everything, *Linux Format.*

Signed, *LibreOffice.*"

OPINION

IT'S BEEN A PLEASURE

"Dear readers, it's not easy to say goodbye, but as we write our final column, we're filled with pride and gratitude for the journey we've shared.

We're especially thankful to everyone who helped make this outstanding publication possible, especially Neil, whose tireless dedication as editor has been nothing short of remarkable.

Collectively, these efforts helped shape the legacy of a magazine that has been an unwavering beacon for the open source community. For years, *Linux Format* has informed, inspired and connected Linux enthusiasts with expert insights, practical tutorials and thought-provoking commentary.

This magazine didn't just document the evolution of free software, it helped shape it, champion it and drive its adoption forward.

While this final issue marks the end of an era, its influence will continue to echo in every line of code, every breakthrough and every collaboration it helped inspire.

Thank you, readers, for being part of the **LXF** story. Whether you've been with us from the beginning, or just joined recently, your passion for open source has helped make this magazine what it is, and what it will continue to be in spirit. And to *Linux Format* itself: thank you. Your impact will never fade.

From all of us at Collabora."

SOFTWARE

Germany adopts ODF

Europe's open source push continues but challenges to adoption remain.

This move echoes adoption of ODF by other countries, such as the UK. However, widespread open source adoption remains elusive.

CREDIT: The Document Foundation

The IT-Planungsrat (IT Planning Council) of Germany has committed to making the Open Document Format (ODF) a country-wide standard for public administration by 2027. This move follows the UK, which formally adopted the ODF in 2014.

Such initiatives haven't always gone smoothly. In 2004, the city of Munich launched the LiMux project in a bid to move away from Windows-based software. Despite migrating over 80% of desktop systems, Munich council reversed its decision in 2017. The city council continued using *LibreOffice* and in 2020 voted to continue favouring open source software.

This move echoes wider developments in the EU to promote open standards and digital independence. This is best shown by the EU OS initiative to develop a Linux-based OS for public sector organisations, based on Fedora.

However, according to the Linux Foundation Europe, only 30% of public organisations have a formal open source strategy. The question remains whether initiatives like EU OS will lead to more widespread open source standards.

SOFTWARE

Keep on forking!

Redis relicensing backfires as open source fork Valkey wins major support.

In March 2024, Redis Labs announced that its software would switch from a permissive BSD licence to a non-free, source-available one. The Linux Foundation promptly said that it would fork the most recent BSD-licensed version of *Redis* as *Valkey*. The fork still uses a BSD-3 open source licence and is supported by Google, AWS and Alibaba.

Arch Linux has now become the latest distro to adopt *Valkey* over *Redis*. In doing so, it has joined other major distros such as Alpine Linux, Fedora and AlmaLinux. Other projects like Ruby on Rails, which previously used *Redis* by default, have also replaced *Redis* with alternative tools.

This aggressive forking is reminiscent of Elasticsearch, which moved away from open source licensing in 2021, prompting AWS to fork the search engine as OpenSearch.

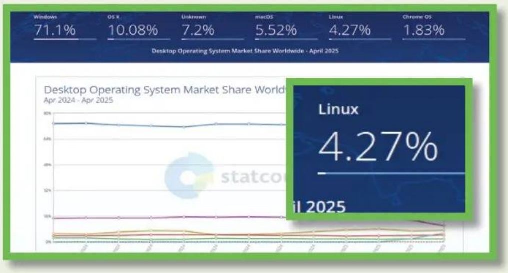
As more distros migrate to forks such as *Valkey* and OpenSearch, the feelings of the community towards open source developers are clear: remain committed to your project values, or you'll be forked.

DISTROS

Year of the Linux desktop!

Windows exodus and Steam boom pushes Linux towards 5% adoption.

Among continuing speculation by open source enthusiasts as to whether this will be the year of the Linux desktop, the OS's market share is 4% globally. It's also hit all-time highs in regions like South America and Africa. This isn't the first time Linux has crossed the 4% threshold but the recent surge is likely down to dissatisfaction with Windows 11, as well as the Steam Deck's popularity. With the Windows 10 sunset due in October, multiple outlets have predicted that Linux may finally break the 5% adoption barrier and sustain it.



Windows 71.1% · OS X 10.08% · Unknown 7.2% · macOS 5.52% · Linux 4.27% · Chrome OS 1.83%

Desktop Operating System Market Share Worldwide - April 2025

Desktop Operating System Market Share World

Apr 2024 - Apr 2025

Linux

4.27%

il 2025

Various factors are boosting Linux's adoption.

CREDIT: StatCounter

Distro watch

What's behind the free software sofa?

ARCHCRAFT 2025.04.24

As the name reveals, this minimal Linux distro is based on Arch Linux. Instead of a traditional desktop environment, it uses a series of minimal window managers. Setup is handled by *Calamares,* and users can use *yay* to install packages from the Arch User Repository. The latest Prime release comes with updated window compositors, including Sway and Wayfire. It also contains bug fixes, including those that were causing the *Polybar* status bar to crash. Learn more at **https://archcraft.io**.

The OS uses window managers instead of a traditional desktop.

ANDUINOS 1.3.0

AnduinOS is based on the latest version of Ubuntu (in this case v25.04), though it doesn't natively support Snap packages. It also deploys a customised version of Gnome 48 to make the user interface resemble Windows 11. The latest version comes with a new shortcut (Super+V) to list the clipboard history. The distribution now includes *Gnome Software,* which itself supports Flatpak installs. It's also now HDR-compatible. A *Firefox* localisation bug has now been fixed. You can read more at **www.anduinos.com**.

Although AnduinOS is based on Ubuntu, it resembles Windows 11.

MABOX LINUX 25.04

This Manjaro-based distro follows a rolling release model. It deploys a custom desktop based on Openbox. The latest version comes with tweaks to the tint2 panel. The dedicated panel icon also now has a revamped thumbnail, as well as new functions to change the wallpaper or other desktop elements. The status indicator has been upgraded to list disk usage, as well as a directory size monitor. This includes key info such as the kernel version. See more at **https://maboxlinux.org**.

Mabox now has a polished interface and better notifications.

DRAGONFLY BSD 6.4.1

While based on the same Unix ideals and APIs, this distribution is a fork of the FreeBSD-5 series, and this latest point release is the first to emerge in over two years. It includes fixes for a number of long-standing bugs, as well as hardware support for type-2 hypervisors with NVMM. There's now an amdgpu driver and an experimental feature to mount HAMMER2 volumes remotely. Version 6.4.1 also comes with a full new set of binary packages. You can discover more at: **www.dragonflybsd.org**.

DragonFlyBSD contains bug fixes and new packages.

ALT LINUX 11.0

This distro came about in 2001 through a merger of two Russian Linux projects, but it has its own development structure and repo, code-named Sisyphus. This provides the basis for various versions of ALT, including this Workstation edition, which now features Gnome. On first login, users can tour features and customise the theme and extensions. The distro can still be booted in live mode using Nouveau drivers. Once installed, it uses Nvidia drivers. See **https://en.altlinux.org** for more.

ALT Linux now ports the Gnome desktop and Qt 6.

OPINION

30 YEARS OF MYSQL

Lori Lorusso
is Percona's head of community.

> On 23rd May 1995, *MySQL* launched as a fork of *mSQL*, and the innovations have not stopped. But what made it so popular? Community, luck and the internet.
>
> Community started with the *MySQL* team. They were determined to help the community get the most out of the project and use it how they wanted. This led to a vibrant community that wasn't afraid to try new things and work hard to make *MySQL* succeed.
>
> Luck is being in the right place at the right time. In the dotcom crash, the US stock market lost over three quarters of its value as high tech companies went bust. The result? The next generation of companies had to build and innovate with low-cost or free software. Enter *MySQL* and a host of other open source projects.
>
> The LAMP stack approach of Linux, Apache, *MySQL* and Perl, Python or PHP led to the creation of the open web and the explosion of sites based on open source.
>
> However, *MySQL* has stagnated and is seen as a legacy database. If *MySQL* wants to keep the number one open source database slot, we need the community to feed the fire of innovation and collaboration. Imagine a future where *MySQL* has a home in an open source foundation giving power to the community the way the team started.

OPINION

ALL GOOD THINGS

Jon Masters is a kernel hacker who's been involved with Linux for over 22 years, and works on energy-efficient ARM servers.

"Growing up, I was a huge fan of *Star Trek: The Next Generation.* I remember coming home from school and tuning into one of the four(!) UK TV stations to watch it. Then, one day, it ended abruptly.

I started writing for Linux magazines in 1999. I did a few reviews in *Linux User & Developer* that became a regular column. It morphed over time into a kernel-focused column, which I wrote for many years. Until it came to an end.

Linux Format was then gracious enough to offer me an opportunity to write a new kernel column. I have enjoyed these past few years immensely. In a time of tremendous uncertainty and change, it has been therapeutic to have the constancy that comes from writing for you each month. It keeps me connected to my roots in the Linux community, and forces me to take time to read many of the emails sent to the Linux Kernel Mailing List (LKML).

As our time draws to an end here, I look back fondly on collaborating with Neil, a highly tolerant editor who is rightly proud of what he did here. As for me, maybe I'll find a landing for a kernel column, but I'll definitely do my best to bring back the kernel podcast I enjoyed making years ago. Maybe you'll tune in."

Kernel Watch

Jon Masters summarises the latest happenings in the Linux kernel, so that you don't have to.

Linus Torvalds announced Linux 6.15-rc5, noting that the Release Candidates (RCs) "continue to look pretty regular". With that in mind, 6.15 final should be released by the time you read this. All was not plain sailing, however, as Linus upgraded to the latest Fedora 42 just prior to posting 6.15-rc3, and with it gained a new compiler (GCC 15) that handles unterminated strings differently from previously. In GCC 15, a string that exactly fits in the allocated space (without room for the implied NULL termination) results in a fatal warning.

Alas, not all such warnings are valid. For example, certain hardware data structures don't have string termination. As a result, Kees Cook had already been working on patches to handle these cases, but Linus's last-minute fixes to address the issue actually broke both older compilers and the fixes that were in progress. As a result, some reverting of the fixes was required and true support for GCC 15 will land in a second wave of patch merging later.

> "A new generation aren't going to be satisfied until core parts of the kernel can be implemented in Rust."

Things to watch...

We might not be here to tell you about them, so here are a few things to keep a look out for in the months and years ahead. Linux development tends to follow certain themes over time. In the early days, it was all about feature parity with commercial Unix (and Windows NT), scaling up to large numbers of CPUs (today, we would say cores), and implementing some fancy scheduler or real-time algorithm. Then came virtualisation, containers and, of course, the adoption of Linux in almost every embedded device, from phones and cars to milking machines and space rovers. Today, Linux is a mature operating system, but that doesn't mean it is sitting still. It does mean the themes change, however.

Over the coming months and years, expect to see a great focus on security and supply chain. Technologies such as confidential compute continue to receive huge focus upstream across all major architectures. Meanwhile, legislative action is driving an interest in sustainably supporting downstream projects shipping Linux kernels that must now be supported (and potentially rebased) for longer. BPF (Berkley Packet Filter) might have started out life as a simple networking tool, but today you can even write Linux scheduler extensions in it. Also, look out for the many efforts related to open source graphics, GPUs, NPUs and, of course, AI. The world is more than just CUDA, but as you saw last month in Nova, there is work to create an open Nvidia GPU driver in Rust.

We couldn't finish without mentioning Rust. For all the controversy (and there is plenty of that), there is significant interest in adoption of Rust by a new generation of programmers who aren't going to be satisfied until core parts of the kernel can be implemented in Rust. Expect to see a lot more action there in the future.

So, that's it, then, at least for now. It's been amazing fun sharing this column with all of you and I hope you've got something out of it, too. I would like to thank Neil and the staff who made this magazine something special. LXF

» ONGOING DEVELOPMENT

Readers will be acutely aware that the world is undergoing some profound and highly disruptive structural changes. As a British-American dual citizen, I have many feelings on the matter best saved for another venue. But alas, the impact of these changes is already being felt in our communities. Recently, the OSL (Open Source Lab) at Oregon State University (OSU) has announced that it is essentially out of money due to funding changes at the university. If your company is looking for a way to give back to the community, it is one of many worthwhile entities that could use our support in these uncertain times we are living in.

UNEARTH THE FULL STORY BEHIND THE LEGEND OF ZELDA

Explore every game in the series and what makes each one so great. If you're a fan, you'll enjoy the trip through time. If you're a newcomer, we offer you this sage advice: "It's dangerous to go alone, take this!"

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Answers

This is the **25th Anniversary edition of Linux Format** and its Answers pages, so here's a selection of some of the more common and interesting questions we have received.

Neil Bothwick takes a well-earned rest and lets his brain cool down.

Q Memory loss

I have forgotten my root password. Is there a way to reset it or will I have to reinstall?
Alex Wade

A All is not lost – there is no need to reinstall. There are at least three ways to reset the root password that we can think of: *sudo,* single-user boot or a live distro. All of them are ways of becoming root without the root password, so that you can then reset it. The simplest, if your distro is set up to use *sudo* with suitable permissions, is to run:

```
$ sudo -i
```

This runs an interactive shell as root, from which you can run the following to set a new password:

```
$ passwd
```

If *sudo* is configured to block this option (it is insecure), you can try booting in single-user mode. Reboot the computer and at the boot menu, press `e` to edit the boot options. If you are running *systemd,* add `systemd.unit=emergency.target` to the end of the kernel options, otherwise either `single` or `emergency` should do the job. As a last resort, try `init=/bin/sh`. One of these will boot you into a root shell, from where you can run the *passwd* command. If *passwd* complains about the root filesystem being mounted read-only, run the following to remount it read/write:

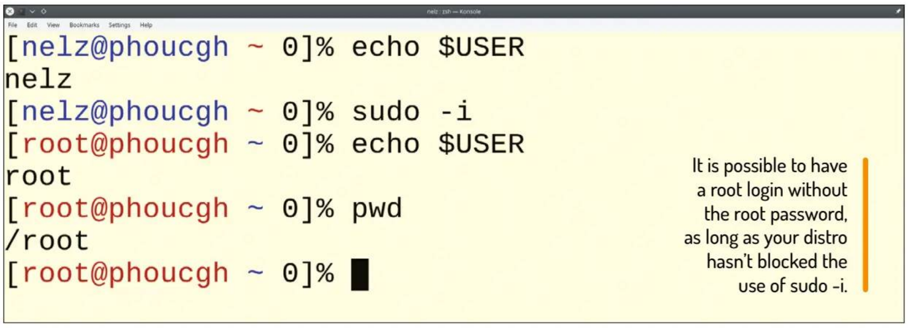
```
$ mount / -o remount,rw
```

Being able to gain root access like this is a security risk if physical access to your computer is possible, so your GRUB menu may be password-protected. If you can remember that password, fine, but if it is the same as the root password, or you are having serious memory problems, you may need to go with the third option.

Boot from a live distro – it could be a rescue distro or just a normal live desktop; use whatever is to hand. Open a terminal and become root in the live environment; use the **sudo -i** option if this is an Ubuntu-ish distro – they allow passwordless *sudo* on the live discs. Now mount your distro's root partition. We'll use **/dev/sda1** for our example here but it is wherever your distro is installed. Then you can *chroot* into the distro – which just means setting the root of the distro as your shell's operating environment and running the command given – and run *passwd:*

```
$ mkdir -p /mnt/distro
$ mount /dev/sda1 /mnt/distro
$ passwd --chroot /mnt/distro
```

Now your new password should be written to the **/etc/shadow** file on your distro. Reboot to try it out – and try not to forget it this time!



```
[nelz@phoucgh ~ 0]% echo $USER
nelz
[nelz@phoucgh ~ 0]% sudo -i
[root@phoucgh ~ 0]% echo $USER
root
[root@phoucgh ~ 0]% pwd
/root
[root@phoucgh ~ 0]% 
```

It is possible to have a root login without the root password, as long as your distro hasn't blocked the use of sudo -i.

Q Big not FAT

I have some very large files I want to move to an external hard drive, but I get an error when I try to copy files much over 4GB. I realise now that I should have re-formatted it to NTFS format when it was new, but it is too late now as it has too much stuff on it.

I have found out about the *split* command, but this seems to be for files with lines in them, unlike mine. Also, I have not been able to get a clear idea of what actual prefixes and suffixes to use. Please note that I want to be able to put the file back together again in 10 or more years' time, so I need commands that are likely to be around for a long time.

What commands should I use to split and re-assemble the files? Is it possible to re-assemble the parts on the external drive? Is it possible to safely reformat the external hard drive without losing the files on it?
Daniel Gough

A The *split* command was intended for text files but it can split binary files, too, with the **-b** option. To split a file into 1GB chucks, you'd use something like:

```
$ split -b 1G largefile largefile.
```

Here, **largefile** is the file to split and **largefile.** is the prefix to use for the pieces. *Split* adds **aa** to the first piece, **ab** to the second and so on, but it does not add a dot before it, so including a dot in the prefix makes the output more readable. Joining the files together again is done with the *cat* command:

```
$ cat largefile.?? >newlargefile
```

You cannot do this on the external drive because the 4GB limit is a limitation of the FAT filesystem not the USB connection. However, this is not the end of it. FAT is not the most reliable of filesystems, and is not ideal for long-term storage. At the very least, you should record checksums for each of the files, so you can test their integrity before joining, like this:

```
$ sha1sum largefile >largefile.sha1
$ for f in largefile.??; do
$   sha1sum $f >$f.sha1
$ done
```

This generates an **sha1** checksum file for the original and each of the pieces that you can copy to the drive. Then you can test them before restoring with:

```
$ sha1sum --check *.sha1
```

If the data is important, it should be copied to more than one drive, ideally kept in separate locations.

Changing the filesystem on the fly is theoretically possible, but you should back up the drive before doing it. Of course, if you have space to back up the drive, you may as well back up, reformat with a more suitable filesystem, and restore. Whatever filesystem you use, there is a risk of data corruption or hardware failure over the years, so the advice to keep at least two copies remains. Additionally, you should regularly test those copies, using the checksums, to ensure they are still viable.

Q Early swap usage

I'm using Kubuntu 19.10 and noticed that swap was used very early after starting the desktop, even if there's still RAM available (4GB RAM, KDE Plasma Desktop). How can I troubleshoot what's causing this early use of swap? Isn't swap supposed to be used only if RAM is full? Can I do something about it?

Leon Butcher

A This is not a problem to be solved, it is the system working as it should. Memory management in Linux is both advanced and mature – years have gone into optimising it. Data is moved from memory to swap because it is unlikely to be needed, but has to remain available in memory in some form. For example, code used when starting up system services may not need to be accessed once those services are running, so it can be safely paged to swap.

Linux tries to use all the memory available to it; RAM not occupied with code or data is used for filesystem caching, to speed up disk usage. So, swapping out unneeded data can make your system faster. It is also worth bearing in mind that if RAM does become short and the system needs to swap out data, it will not automatically swap it back in once RAM becomes free – there is no point in doing that until it is needed, otherwise it only has to swap it out again the next time something demanded more RAM.

4GB is not considered a lot of RAM nowadays, especially when using a heavyweight desktop like KDE. It is certainly sufficient but your system is doing its best to make sure that as much as possible of that RAM is available for use. As long as your system is not frequently moving data to and from swap, which will really slow things down, your system is working as it should. Use a memory monitor, either one of the graphical ones like *KSysGuard* or the terminal command `free -h`, to see what is going on.

I would be more worried if swap was not being used, as it would mean that unnecessary code was being allowed to take up RAM instead of using the more suitable resources available to it – swap is there to be used.

Q Talking to Android

I struggle to copy files to recent Android devices. They have ditched the ability to mount the phone's storage as a USB device and insist we use MTP. I have tried with MTP but have found it slow and unreliable. So, I wondered if there was an easy way to copy files over Wi-Fi. By easy I mean something that doesn't involve the intricacies and incantations associated with the likes of *Samba*.

Phil Wheeler

A I share your frustration with MTP – sometimes it works well, other times it just stops when it is least convenient. Mounting as USB storage was always a bad idea, because it meant the storage had to be unmounted on the phone first, which meant that programs stopped working. You cannot have two systems accessing the same mounted filesystem without breaking something.

There are a number of options if you want to copy over wireless. If you want to keep directories in sync between your desktop and phone, such as music or photo collections, *Syncthing* (**https://syncthing.net**) is a good choice. We had a tutorial on this in **LXF203**. For 'manual' file copying, SSH is easy to use, especially if you already have it set up on your computer. Some Android file managers, such as *ES File Explorer,* support SSH or SFTP connections (SFTP is the file transfer part of SSH). These let you access the contents of your computer on the mobile device. You do, of course, need the SSH server installed on your computer; many distros only install the client by default, so install the **openssh-server** or similarly named package.

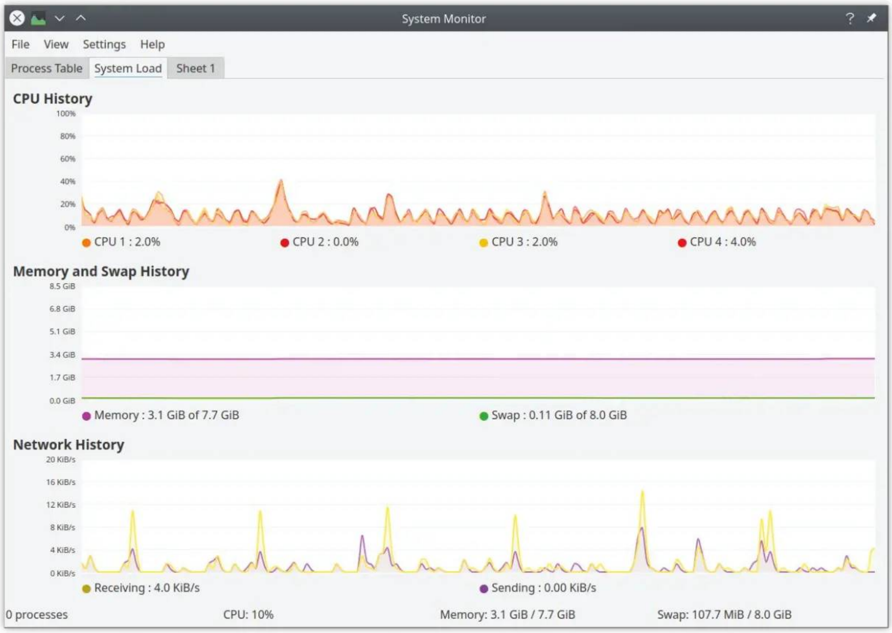
Alternatively, you can do things the other way round, by installing *SSH Helper* from the Play Store. This is an SSH server that supports *scp, sftp* and *rsync.* It runs on port 2222 rather than the more standard port 22, because root access is needed to open ports below 1024. This means you have to specify the port, using **-p** with SSH and **-P** with *scp* or *sftp.* Now you can copy your files to and from the device using *scp* or *rsync,* or you can view the contents of the device in most graphical file managers by pointing them to **sftp://IP-ADDRESS:2222**.

Set a password in *SSH Helper's* settings screen (you need to restart the server after doing this) but the username is irrelevant, so you can leave it out and let SSH default to using your current username. *SSH Helper* has one more trick up its sleeve: you can have it mount your device with *sshfs.* You may need to install *sshfs* on your computer first, then run:

```
$ sshfs -p 2222 IP-ADDRESS:/storage/emulated/0 ~/android
```

You may need to change the path to the internal storage – the above works for recent Nexus devices – and make sure the mount point you use exists and is empty. Now you have your device mounted on the computer, just like in the old USB storage days. When you are done, unmount it with one of the following:

```
$ sudo umount ~/android
$ fusermount -u ~/android
```



While swap usage is usually low, more of it being used is not a bad thing. The only time it should affect performance is when data is being frequently moved in and out of swap.

Q Too many to count

I have a folder potentially containing tens of millions of files. I want to empty this folder– it is on the

root filesystem, so reformatting is not a solution.

Using `rm -rf *` inside the folder fails after about 24 hours – *rm* starts consuming all the RAM in the machine and gets killed. Neither does `rm -rf directory` do any better – after 24 hours, it gets killed as it starts consuming all the RAM in the machine. This is for a Centos machine with a Core 2 Duo Intel CPU and 8GB of RAM. Also, after 24 hours, *rm* has not started deleting even one file from this folder. Running *ls* also dies after about 20 hours of trying to list the directory.

I know that folder potentially contains millions upon millions of files because it is for *Postfix* and we kind of forgot we ran *Postfix* on the machine.

Kieran Brooks

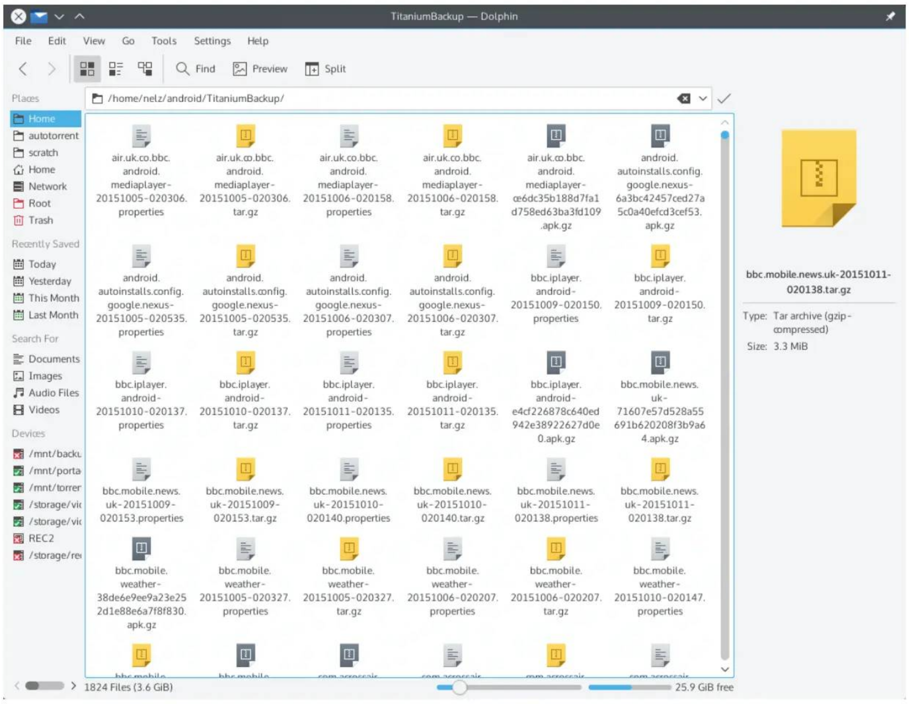
A When using *ls* or a * wildcard, the software first tries to build a list of all the files in the directory. This uses up more and more RAM until it is all gone, then it starts using swap memory, much more slowly. Eventually, even that runs out and it aborts due to insufficient memory to complete its task.

What you then need is a program that will delete files as it finds them, without trying to force any order on them, and you can do this with *find:*

```
$ find /directory/to/empty -type f -delete
```

The *find* command searches the given path and returns all matching files in the order it finds them. As there are no match criteria given, this is everything in the given directory. The **-delete** option then does exactly what you would expect it to (not all Linux commands have cryptically named options). This will still take a while, because deleting millions of files is not a trivial task, but it will not use up all your resources in the process.

Because this command deletes the files as it finds them, you should also be able to interrupt it with Ctrl+C, should you need to stop the process, and you will see that space is already freed up after a short time of running.


TitaniumBackup — Dolphin
File
Edit
View
Go
Tools
Settings
Help
Find
Preview
Split
Places
/home/nelz/android/TitaniumBackup/
Home
autotorrent
scratch
Home
Network
Root
Trash
Recently Saved
Today
Yesterday
This Month
Last Month
Search For
Documents
Images
Audio Files
Videos
Devices
/mnt/backu
/mnt/porta
/mnt/torrer
/storage/vi
/storage/vi
REC2
/storage/re
air.uk.co.bbc.android.mediaplayer-20151005-020306.properties
air.uk.co.bbc.android.mediaplayer-20151005-020306.tar.gz
air.uk.co.bbc.android.mediaplayer-20151006-020158.properties
air.uk.co.bbc.android.mediaplayer-20151006-020158.tar.gz
air.uk.co.bbc.android.mediaplayer-ce6dc35b188d7fa1d758ed63ba3fd109.apk.gz
android.autoinstalls.config.google.nexus-6a3bc42457ced27a5c0a40efcd3cef53.apk.gz
android.autoinstalls.config.google.nexus-20151005-020535.properties
android.autoinstalls.config.google.nexus-20151005-020535.tar.gz
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bbc.mobile.news.uk-71607e57d528a55691b620208f3b9a64.apk.gz
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bbc.mobile.news.uk-20151010-020140.tar.gz
bbc.mobile.news.uk-20151011-020138.properties
bbc.mobile.news.uk-20151011-020138.tar.gz
bbc.mobile.weather-38de6e9ee9a23e252d1e88e6a7f8f830.apk.gz
bbc.mobile.weather-20151005-020327.properties
bbc.mobile.weather-20151005-020327.tar.gz
bbc.mobile.weather-20151006-020207.properties
bbc.mobile.weather-20151006-020207.tar.gz
bbc.mobile.weather-20151010-020147.properties
bbc.mobile.news.uk-20151011-020138.tar.gz
Type: Tar archive (gzip-compressed)
Size: 3.3 MiB
1824 Files (3.6 GiB)
25.9 GiB free

Viewing the contents of an Android phone on the desktop, thanks to SSH Helper.

Q Print and print again

I printed a web page, a receipt for a transaction, then closed the browser tab. The printer is in another room and I only found out later that it had jammed and not printed the page correctly. I can't get the web page back up – is there any way to tell the print system to reprint the last page in a case like this?

Ewan Harding

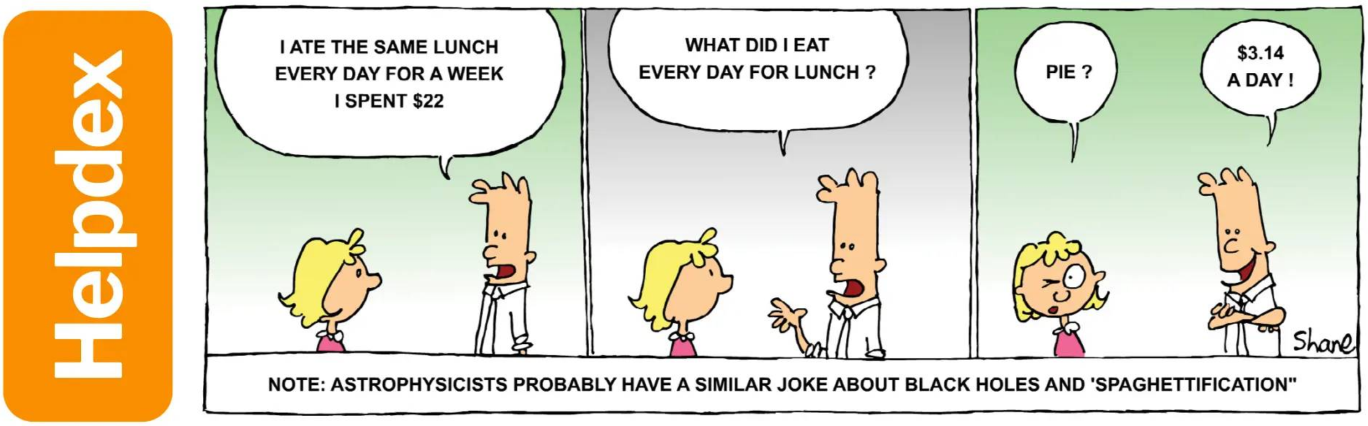
A The good news is that you can do this. The even better news is that you may still be able to retrieve the print job you mentioned. This can be done through the CUPS web interface or on the command line. Point your web browser at **https://localhost:631** (if you are using a print server, use the address of that), then click on Jobs in the top menu and press the Show Completed Jobs button. You should see a list of recent print jobs, with the most recent at the top. If the print job is still in the CUPS cache, there will be a Reprint Job button, which does exactly what it says.

If you scan back to when you had the failed print, you may find that this job has a reprint button, although that is unlikely with most distros using the default CUPS configuration. This is to keep up to 500 jobs but only for a maximum of one day. If you go to the Administration tab in CUPS and click the Advanced link under Server Settings, you can increase this – but, of course, it only applies to future prints.

You can also do the same thing from a terminal, which means you could script it. The *lpstat* command lists your completed print jobs:

```
$ lpstat -W completed | less
```

We pipe it through a pager like **less** because there are 500 entries. Each


Helpdex
I ATE THE SAME LUNCH EVERY DAY FOR A WEEK I SPENT $22
WHAT DID I EAT EVERY DAY FOR LUNCH ?
PIE ?
$3.14 A DAY !
Shane
NOTE: ASTROPHYSICISTS PROBABLY HAVE A SIMILAR JOKE ABOUT BLACK HOLES AND 'SPAGHETTIFICATION"

job has an ID in the first column. You can reprint this job, providing it is still in CUPS's cache, with:

```
$ lp -i ID -H restart
```

If you think this is something you may need to do from time to time, you could create a short shell script containing:

```
#!/bin/sh
lpstat -W completed | head -n1 | awk
'{print $1}' | xargs -I {} lp -i {} -H restart
```

Save it somewhere in your path, make it executable and you will be able to reprint the last job whenever you need without having to refer back to this answer.

Mail without an MTA?

Q **I use a Debian computer as a NAS to back up important files daily over the LAN. I'd like to add a cron job so the NAS checks disk usage, and sends an email the day the disk is 80% full. Is there a way to send an email without setting up an MTA server, like *Sendmail, Postfix* and so on?**
Robert

A You could have your checking script talk directly to an SMTP server at your ISP. How you do this depends on the language you choose. Alternatively, you can install a relaying mail server. Unlike *Postfix* et al, these simply forward emails to a server elsewhere, which is why they are often called forwarding mail servers. Examples of these include *ssmtp* and *nullmailer.* Going with *nullmailer*, you need to configure the files in **/etc/nullmailer**, the most important of which is **remotes**. This file contains a number of commented examples, but for a straightforward SMTP setup, you only need one line:

```
mail.myisp.com smtp
```

The **remotes** file must not be world-readable. *Nullmailer* runs as a daemon, so you need to make sure it is always running. If your distro uses *systemd,* this will start the daemon and make sure it is fired up every time you boot. The following commands show you if it is working and any error messages or warnings:

```
$ sudo systemctl enable --now nullmailer.
service
$ sudo systemctl status nullmailer.service
```

You may also need to issue a restart command after editing the config files.

Once *nullmailer* is running, you can use the standard *mail* command to send mail, or any other software that talks to a local mail server:

```
$ echo "mail body" | mail -s "Message
subject" you@email.com
```

Restricted SSH

Q **I have two servers that I want to be able to run commands on over SSH without entering a password. I believe it is possible to set up SSH without a password but I would rather not give unrestricted access to my servers. Can I restrict SSH sessions to just the command I want to use?**
Sam Wallis

A You can allow passwordless logins over SSH by using keys. The first step is to generate SSH keys on the client machine – if you have not already done so – with this command:

```
$ ssh-keygen -t ed25519
```

When prompted for a passphrase, just press Enter. We have used the **ed25519** key type here, the man page details the other options but this is a good one to use. You have generated a two-part key in **~/.ssh**, now you need to copy the public part of this to the server, where it is stored in the **~/.ssh/authorized_keys** file. You could edit the file manually but there is a command to do this. On the client, run:

```
$ ssh-copy-id -i ~/.ssh/id_ed25519.pub
user@server
```

It asks for that user's password on the server and then copies the file. Repeat the copy process for each of the servers. This gives passwordless access to your servers. It is not unrestricted – only your user on your client machine can gain access, and only as the remote user to which the ID was copied. But that user can then run any command. You can set an SSH key to only be used for a single command in the **authorized_keys** file by adding `command="/path/to/command"` to the start of the line giving the key, so it looks something like:

```
command="/path/to/command" ssh-
ed25519 AAA..... user@hostname
```

When that user connects via SSH, the specified command is run immediately, and commands given on the SSH command line are ignored. While mainly a security measure, it's also a convenient way of setting up short aliases to complex commands by setting a Host entry **~/.ssh/config** that says to use the SSH key that's locked to the command you want.

For further security, you can disable all other SSH logins by that user, even with a password. Edit **/etc/ssh/sshd_config** on the remote machine to set:

```
Match User username
 PasswordAuthentication no
```

GO HELP YOURSELF

That's it we're done, after twenty-five years of delivering multi-months late help to our patient readers *Answers* can finally head to the great magazine help section in the sky. We can't thank Neil Bothwick enough for his steady management over the years.

It doesn't have to end here, there's a world of Linux self-help out there on the wild internet. Near endless forums and useful communities that love explaining exactly what you're doing wrong!

As always answers are just a Duckduckgo away. It does help to go armed with details, consider installing *hardinfo* or *lshw.* These programs list the hardware on your machine, so use their output. If you're unwilling, or unable, to install these, run the following commands in a root terminal and send us the **system.txt** file, too.

```
uname -a > system.txt
lspci >> system.txt
lspci -vv >> system.txt
```

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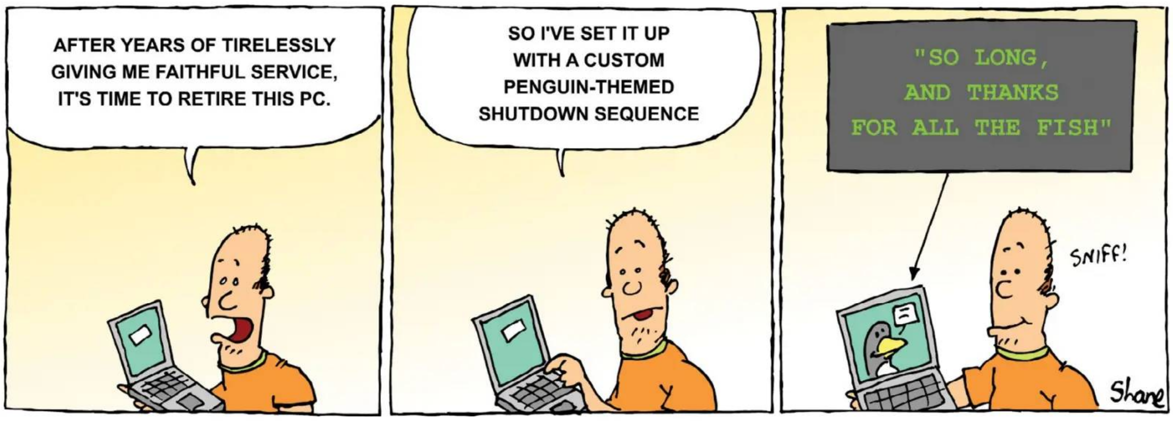

AFTER YEARS OF TIRELESSLY GIVING ME FAITHFUL SERVICE, IT'S TIME TO RETIRE THIS PC.
SO I'VE SET IT UP WITH A CUSTOM PENGUIN-THEMED SHUTDOWN SEQUENCE
"SO LONG, AND THANKS FOR ALL THE FISH"
SNIFF!
Shane

shane_collinge@yahoo.com

25 years of Linux Format

Corel Linux 1.0

Corel's entry into the Linux market has potential, but there are issues.

IN BRIEF

A short-lived Debian-based distro from Corel aiming to compete with Windows 98/2000. The project ceased not long after Microsoft bought 24 million Corel shares around October 2000. Hmmm…

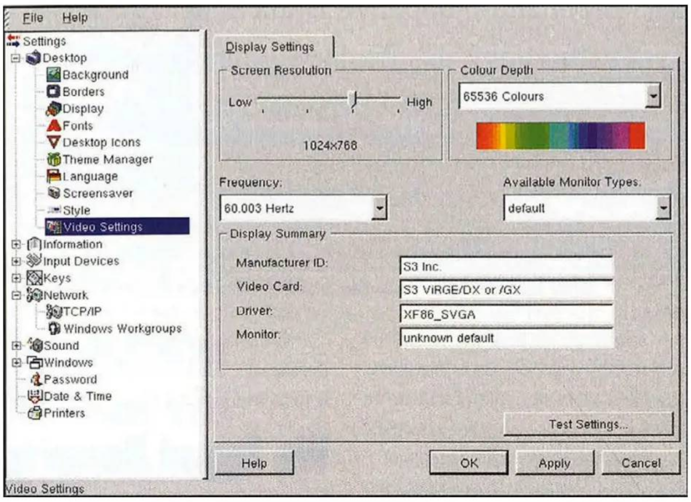
SPECS

Released: Nov 1999
CPU: Pentium class
Mem: 24MB
HDD: 500MB
Builds: x86

We've dug out our classic distro reviews from LXF001, May 2000, so we can remeber just how far the Linux desktop has come! When Corel announced it would move into the Linux market, the news was greeted with both hope and apprehension by the community. While it was clear the organisation could help to improve Linux's position on the desktop, many thought it was in danger of dumbing down the operating system.

The software company, responsible for *WordPerfect* and *CorelDRAW,* has based its package on the respected Debian distribution, and aimed it at new users who have switched from Windows. Corel's graphical installer is a welcome feature for new Linux users and those who have switched from Windows, featuring mouse and dialog-driven configuration.

As well as taking over the whole hard drive, you can also install directly into a Windows directory. However, our system froze just after it had copied the files on to our drive, and reports from other users in the main Linux newsgroups confirm that this is common problem. According to the detailed support pages on Corel's website, these difficulties are due to hardware probing. Fortunately, though, the files were already in place on our drive, so we were still able to start Corel Linux up.


File
Help
Settings
Desktop
Background
Borders
Display
Fonts
Desktop Icons
Theme Manager
Language
Screensaver
Style
Video Settings
Information
Input Devices
Keys
Network
TCP/IP
Windows Workgroups
Sound
Windows
Password
Date & Time
Printers
Display Settings
Test Settings...
Help
OK
Apply
Cancel
Video Settings

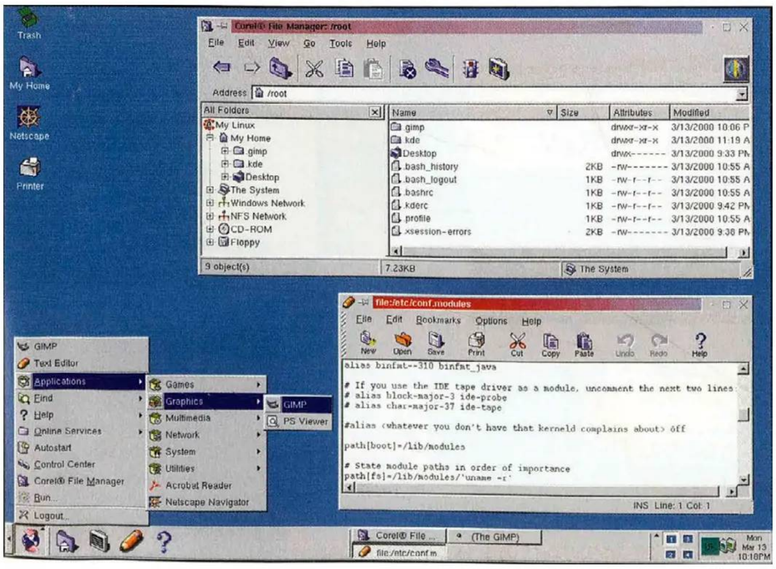
Screen Resolution: Low — High, 1024x768
Colour Depth: 65536 Colours
Frequency: 60.003 Hertz
Available Monitor Types: default
Display Summary
Manufacturer ID: S3 Inc.
Video Card: S3 ViRGE/DX or /GX
Driver: XF86_SVGA
Monitor: unknown default

Network and video configuration can be done from the control panel.

Our system froze just after it had copied the files on to our drive...

Desktop details

Corel's desktop is based on KDE, with various tweaks and enhancements. The most significant addition is the *Corel File Manager,* which resembles Windows Explorer and provides a familiar interface for new users. *FVWM 95* is also included as an alternative. The *XFree86* version is 3.35, and also supplied is *GIMP 1.0.2, Netscape 4.7* and *Adobe Acrobat Reader.* This is a reasonable range of desktop applications, although adding extra software is trickier because Corel Linux uses DEB packages, rather than RPMs (which most of the other distributions use). Still, there are many Debian packages around and the supplied *Alien* tool can convert RPMs to the native DEB format. For more advanced users, the GCC compiler and *Midnight Commander* file manager are also available.


Trash
My Home
Netscape
Printer
Corel® File Manager: /root
File
Edit
View
Go
Tools
Help
Address
All Folders
My Linux
My Home
The System
Windows Network
NFS Network
CD-ROM
Floppy
9 object(s)
7.23KB
The System
file:/etc/conf.modules
File
Edit
Bookmarks
Options
Help
New
Open
Save
Print
Cut
Copy
Paste
Undo
Redo
Help
INS Line: 1 Col: 1
GIMP
Text Editor
Applications
Find
Help
Online Services
Autostart
Control Center
Corel® File Manager
Run...
Logout...
Games
Graphics
Multimedia
Network
System
Utilities
Acrobat Reader
Netscape Navigator
GIMP
PS Viewer
Corel® File ...
(The GIMP)
file:/etc/conf.m
Mon
Mar 13
10:18PM

Address: /root

```
Name              Size  Attributes   Modified
gimp                    drwxr-xr-x   3/13/2000 10:06 P
kde                     drwxr-xr-x   3/13/2000 11:19 A
Desktop                 drwx------   3/13/2000 9:33 PM
.bash_history     2KB   -rw-------   3/13/2000 10:55 A
.bash_logout      1KB   -rw-r--r--   3/13/2000 10:55 A
.bashrc           1KB   -rw-r--r--   3/13/2000 10:55 A
.kderc            1KB   -rw-r--r--   3/13/2000 9:42 PM
.profile          1KB   -rw-r--r--   3/13/2000 10:55 A
.xsession-errors  2KB   -rw-------   3/13/2000 9:38 PM
```

```
alias binfmt--310 binfmt_java

# If you use the IDE tape driver as a module, uncomment the next two lines:
# alias block-major-3 ide-probe
# alias char-major-37 ide-tape

#alias <whatever you don't have that kerneld complains about> off

path[boot]=/lib/modules

# State module paths in order of importance
path[fs]=/lib/modules/`uname -r`
```

Problems...

This is a promising distribution and Corel appears to have worked hard in many key areas. While there's little variety in the available desktops, the ability to perform X and network configuration through the KBE control panel is a bonus. Advanced users may feel restricted, however, and the sheer number of installation problems we've come across and heard about makes it difficult for us to recommend it. If Corel can sort out these troubles and produce a reliable installer in its release, Corel Linux will be worth keeping an eye on. LXF

VERDICT

DEVELOPER: Corel
WEB: http://linux.corel.com
LICENCE: GPL, Various

FEATURES	**8/10**	**EASE OF USE**	**6/10**
PERFORMANCE	**6/10**	**SOFTWARE**	**8/10**

Has potential but needs work on the troublesome installer.

» Rating 6/10

Debian GNU/Linux 2.1

It may be a bit behind the times, but Debian is one of the best distributions on the market.

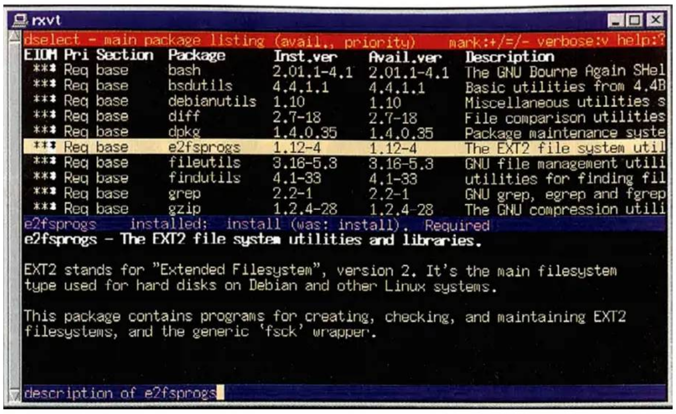
IN BRIEF

One of the grandparents of Linux distros, first released in 1993 by the sadly deceased Ian Murdock. Its name is a portmanteau of Ian and Debra, and it uses *Toy Story* characters for release code names.

SPECS

Released: March 1999
CPU: i386
Mem: 12MB
HDD: 64MB
Builds: x86, Alpha, Sparc, 68k, ARM

Unlike commercial distributions, Debian is produced by a non-profit organisation called Software in the Public Interest. Volunteers all over the world help to maintain the system, and the distribution has acquired considerable respect from experienced users in the community. The text-mode installer is available in mono or colour, so Debian can be installed on very old systems that don't have colour displays. This is a good idea and a refreshing change from the new, jazzy installers we're seeing everywhere else.



```
rxvt
dselect - main package listing (avail., priority)      mark:+/=/- verbose:v help:?
EIOM Pri Section  Package      Inst.ver     Avail.ver    Description
 *** Req base     bash         2.01.1-4.1   2.01.1-4.1   The GNU Bourne Again SHel
 *** Req base     bsdutils     4.4.1.1      4.4.1.1      Basic utilities from 4.4B
 *** Req base     debianutils  1.10         1.10         Miscellaneous utilities s
 *** Req base     diff         2.7-18       2.7-18       File comparison utilities
 *** Req base     dpkg         1.4.0.35     1.4.0.35     Package maintenance syste
 *** Req base     e2fsprogs    1.12-4       1.12-4       The EXT2 file system util
 *** Req base     fileutils    3.16-5.3     3.16-5.3     GNU file management utili
 *** Req base     findutils    4.1-33       4.1-33       utilities for finding fil
 *** Req base     grep         2.2-1        2.2-1        GNU grep, egrep and fgrep
 *** Req base     gzip         1.2.4-28     1.2.4-28     The GNU compression utili
e2fsprogs    installed;  install (was: install).  Required
e2fsprogs - The EXT2 file system utilities and libraries.

EXT2 stands for "Extended Filesystem", version 2. It's the main filesystem
type used for hard disks on Debian and other Linux systems.

This package contains programs for creating, checking, and maintaining EXT2
filesystems, and the generic 'fsck' wrapper.



description of e2fsprogs
```

Dselect, Debian's package management system, listing the installed software.

Are you experienced?

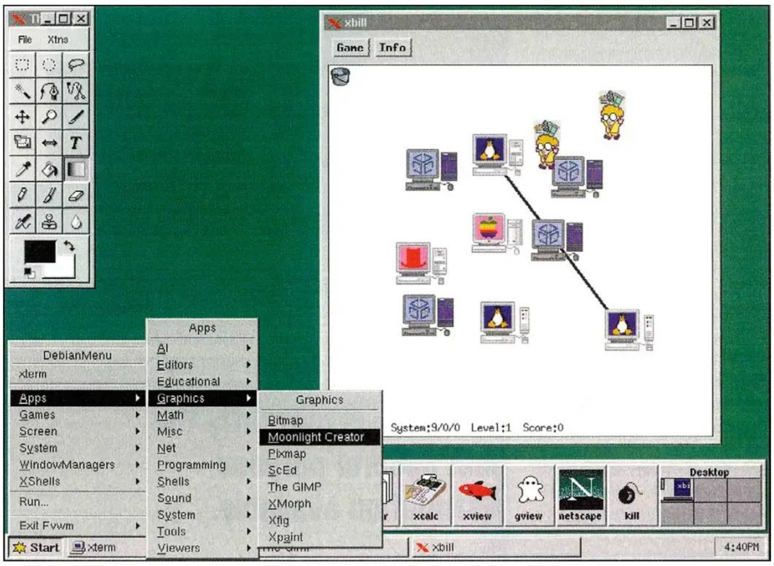
From the very start, it's clear that new users would find this heavy-going. The *Cfdisk* partitioner assumes plenty of knowledge and there's little of the hand-holding you get with others. Conversely, you're constantly prompted and alerted as to what the installer is doing, which is a world apart from the 'do everything automatically' idea behind distributions such as Corel.

The installation takes some time because after choosing one of the package categories (desktop, development workstation and so on), you have to sit through the post-install configuration and occasionally answer questions for each package. Debian uses the DEB format, which is similar to RPM. However, with the extensive *Dselect* package management tool, adding and removing software is straightforward. The best feature of all is *APT* (Advance Package Tool), which enables the entire system to be updated with just a few commands. After experiencing incompatibilities with RPMs from various distributions, we were glad to see such painless upgrading and package control. On the software side, Debian is showing its age. The supplied kernel is 2.038 – not even from the 2.2.x series – and *XFree86* is back at 3.3.2. An old version of Gnome is supplied, along with several window managers, such as *Enlightenment Window Maker* and *FVWM*. Being a technically orientated distribution, many console programs that don't need X are included, with mail applications, development tools and network utilities.

The Debian CD's packages are slightly behind the times for a few reasons. Firstly, as it's a volunteer project, the developers can't just throw out another release whenever possible. More importantly, they are concerned with the stability and maintenance of a working system, as seen by the excellent upgrade procedure. This development process and general attitude is similar to that of the kernel itself – technical excellence takes preference over commercial interests.

Debian is not a good choice for Linux beginners, and if you're starting out for the first time, you'll have an easier introduction with Mandrake or Caldera. However, for experienced Linux users who need a very reliable, easily maintainable and carefully crafted distribution, this is the best you can get. **LXF**

FVWM 95 is a fast and small window manager, emulating the look of Windows 9x.



VERDICT

DEVELOPER: Debian Project
WEB: www.debian.org
LICENCE: GNU GPL, various

FEATURES	**9/10**	**EASE OF USE**	**4/10**
PERFORMANCE	**6/10**	**SOFTWARE**	**9/10**

Not suitable for new users, but technically superb and easily maintainable.

» Rating 9/10

25 years of Linux Format

SUSE Linux 6.3

We test this long-established German company's latest distribution effort. Can it hold off the competition?

IN BRIEF

Another of the grandparent distros, SUSE is perhaps mentioned less than others as it's German-based. Because it also focuses on enterprise, it was picked up by Cray for its supercomputers in the early 2000s. It rebranded to OpenSUSE in 2005 and SUSE Linux Enterprise in 2004.

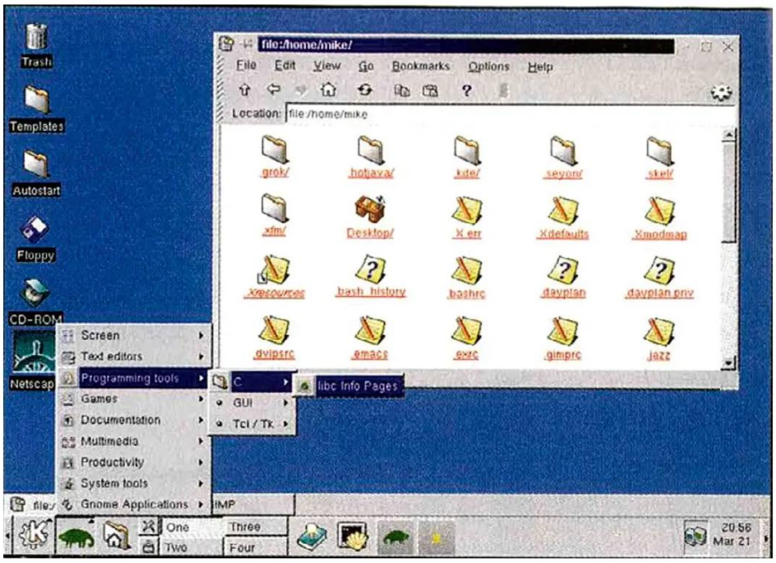
SPECS

Released: Nov 1999
CPU: x86 (i386+)
Mem: 32MB
HDD: N/A
Builds: x86, ARM, S390, PPC

KDE with the SUSE menu, automatically generated from the installed applications.

As an experienced distributor, German company SUSE has been around for many years and is very popular in European markets. One of the reasons for this is undoubtedly due to the large amount of software found on its CDs. It has also recently converted its distribution to run on the Alpha processor, and it has put money into several of the key areas of Linux development.

SUSE's installer is based on *YaST,* a long-running setup utility that has finally been updated from text mode to a full graphical installation. Sadly, when we started our installation, it told us our 2GB partition was too small for the minimum installation. Wisely, though, SUSE has also included the original tried-and-tested *YaST,* and this worked properly. Installation is reasonably quick, although it isn't very neat – first *YaST* starts, then exits to restart the system services, then it starts again, then exits and waits for a minute before running some scripts. However, it's a reasonably simple installation and the online help is thorough and useful.

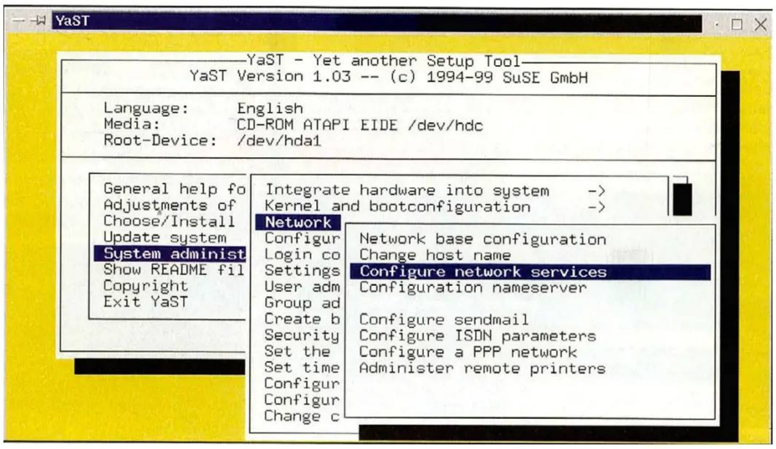

Trash
Templates
Autostart
Floppy
CD-ROM
Netscap
file:/home/mike/
File Edit View Go Bookmarks Options Help
Location: file:/home/mike
grok/
hotjava/
kde/
seyon/
skel/
xfm/
Desktop/
X.err
Xdefaults
Xmodmap
Xresources
bash_history
bashrc
dayplan
dayplan.priv
dvipsrc
emacs
exrc
gimprc
jazz
Screen
Text editors
Programming tools
Games
Documentation
Multimedia
Productivity
System tools
Gnome Applications
C
GUI
Tcl / Tk
libc Info Pages
One
Two
Three
Four
20:56
Mar 21

The YaST tool assists with the administration and configuration of your hardware.

Configuration tools

YaST is also the main system configuration tool in SUSE, offering different administrative and setup options, from adding new users to configuring modems. For the most part, it's easy to use and powerful, although occasionally it didn't do exactly as commanded, and if you're editing configuration files by hand, it can have trouble working with them. Like others, SUSE has opted for KDE by default. It is set up fairly well, with icons for the disk drives and easy access to *YaST* and the help system. One particularly nice feature is the automatic updating of menus – install a new application through *YaST* and it adds an entry to the KDE menu. This can also work for the *FVWM* and *IceWM* menus (among others).

SUSE Linux uses the RPM package format, but we had compatibility troubles installing many off the web. Thankfully, SUSE provides an excellent service on its website for new KDE programs, which are tailor-made to fit the distribution. One cause for concern we noticed was the inclusion of *GIMP 1.1.11,* which is a development version. The program's docs say that it's an unstable version "intended for developers only", so it seems SUSE is chasing version numbers here. This is a shame, but a good, wide range of software for both desktop and server is included, which makes up for it. In all, SUSE is a generally good distribution with some attractive features. Unfortunately, some of its quirks hold it back slightly. LXF



```
                 YaST - Yet another Setup Tool
          YaST Version 1.03 -- (c) 1994-99 SuSE GmbH

   Language:       English
   Media:          CD-ROM ATAPI EIDE /dev/hdc
   Root-Device:    /dev/hda1

   General help fo  Integrate hardware into system     ->
   Adjustments of   Kernel and bootconfiguration       ->
   Choose/Install   Network
   Update system    Configur  Network base configuration
   System administ  Login co  Change host name
   Show README fil  Settings  Configure network services
   Copyright        User adm  Configuration nameserver
   Exit YaST        Group ad
                    Create b  Configure sendmail
                    Security  Configure ISDN parameters
                    Set the   Configure a PPP network
                    Set time  Administer remote printers
                    Configur
                    Configur
                    Change c
```

VERDICT

DEVELOPER: SUSE
WEB: www.suse.com
LICENCE: GNU GPL, various

FEATURES	8/10	**EASE OF USE**	8/10
PERFORMANCE	9/10	**SOFTWARE**	8/10

A decent distribution with some clever features and a wide choice of software.

» **Rating 8/10**

Ubuntu 5.04

25 years of Linux Format

Andy Hudson hopes this is one hedgehog that won't get squashed.

IN BRIEF

Ubuntu is a Debian-based distro that first appeared in 2004, backed by Mark Shuttleworth, a South African entrepreneur who created Canonical, which develops it. Its ease of use and support of the wider ecosystem helped propel Ubuntu and a huge number of spin-off distros to the fore.

SPECS

Released: April 2005
CPU: x86
Mem: 32MB
HDD: 110MB
Builds: IA-32, x86-64, PPC, Arm

This review originally appeared in **LXF068**, so only 20 years ago! The Ubuntu team only launched its first release (4.10, aka The Warty Warthog) in October 2004. Since then, Ubuntu has become one of the most downloaded distros available today. What's its secret? The slogan says it all: Linux for human beings. This is a distro that you shouldn't have to be a geek to use. Version 5.04 – The Hoary Hedgehog – comes on a single CD and doesn't even use its full capacity. It doesn't baffle the new user with a puzzle of software choices. In fact, you don't even select individual packages for installation; you're given a predetermined set of software recommended by Ubuntu.

First, we upgraded our test laptop from Warty using *Synaptic*. Ubuntu is based on Debian, which, as **LXF** readers are aware, has a superb package management tool in *APT*. After *Synaptic* downloaded and installed 798 packages (approximately 400MB), Ubuntu upgraded itself flawlessly. Moving seamlessly from Gnome 2.8 to Gnome 2.10 shows the strength of *APT* and how smoothly it handles dependency issues. After about an hour, *Synaptic* proclaimed that it had finished.

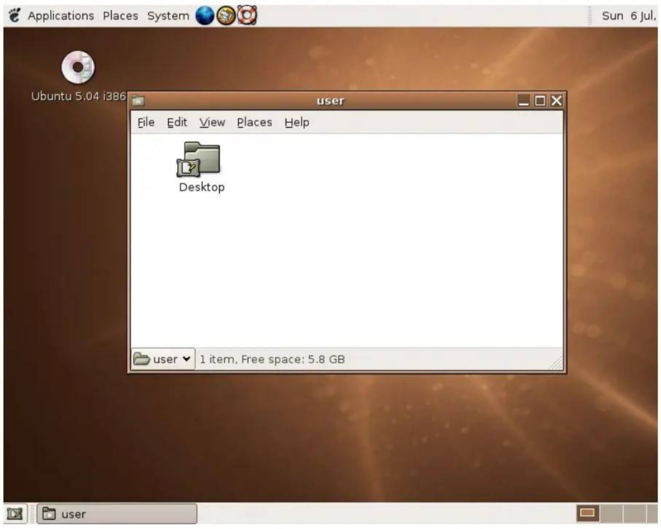
We decided to press ahead and do a fresh install from scratch. Booting directly from the CD takes you into a text installer. Prior to installation, we had resized the existing NTFS to allow space for Ubuntu. At this stage, you have to be very careful – the default choice for Ubuntu is to erase all partitions on the disk. When you're past the partition setup, Ubuntu dives in and starts to copy packages across to the hard drive. All in all, it took about 15 minutes from start to finish, including first boot and letting *APT* set up the software.

The new black?

Once Ubuntu has finished its work, you are presented with the GDM login prompt, resplendent in… brown. Yes, the colour scheme from Warty has been carried forward into Hoary; it seems Ubuntu is quite fond of the look and feel of brown. Regular Gnome users will probably be quick to change it, but the brown isn't so bad, giving a slightly earthy feeling.

Regardless of colour, the user interface is classic Gnome 2.10 complete with Applications, Places and System menus. Evidence of Gnome's maturity is apparent in that all three of the menu options in 2.10 were previously available under the two menus of Gnome 2.8 but they feel more accessible here – they're not buried under lots of menus.

Another key part of Ubuntu is the policy of disabling the root account by default and using only *sudo* to access system commands. Recognising that the majority of people who will use Ubuntu will be installing it at home, the project team took the decision to allow ordinary users to make system-wide changes.


Applications Places System
Sun 6 Jul,
Ubuntu 5.04 i386
user
File Edit View Places Help
Desktop
user
1 item, Free space: 5.8 GB
user

Look beyond the brown Human theme to see a solid Debian-based distro and a fresh approach to Linux.

While purists may recoil in horror from this, if a user tries to open a program that requires *sudo,* they are prompted for a password, making it clear to them that they are making important changes to the system.

Offering a standard suite of apps with no initial variation helps you make the transition as painlessly as possible. Advocates of choice will complain that this prevents users from being able to pick their own software. This may be true, but what's important to the new user is that they do not get swamped by choice.

Perhaps most alluring is the fact that with Ubuntu you get the best parts of Debian, which makes things such as package management absurdly easy. Powerful and extremely usable, Ubuntu has much to offer both new and old users. It's Linux for human beings and geeks, if you like. This is only its second major release, but things are ticking along very nicely. LXF

VERDICT

DEVELOPER: Canonical
WEB: www.ubuntu.com
LICENCE: GNU GPL

FEATURES	7/10	EASE OF USE	8/10
PERFORMANCE	8/10	DOCUMENTATION	7/10

Ubuntu's writers have achieved a lot in the last six months. Give this release a chance and you will not be disappointed.

» **Rating 8/10**

25 years of Linux Format

Linux-Mandrake 7

Simplicity and a wide range of applications make this a great distribution for all Linux users.

IN BRIEF

Mandrake was, for a time, a highly successful spin of Red Hat Linux combined with KDE, developed initially by Gaël Duval. It was succeeded by OpenMadriva and Mageia.

SPECS

Released: 2000
CPU: 586 (Pentium)
Mem: 32MB
HDD: 300MB
Builds: x86

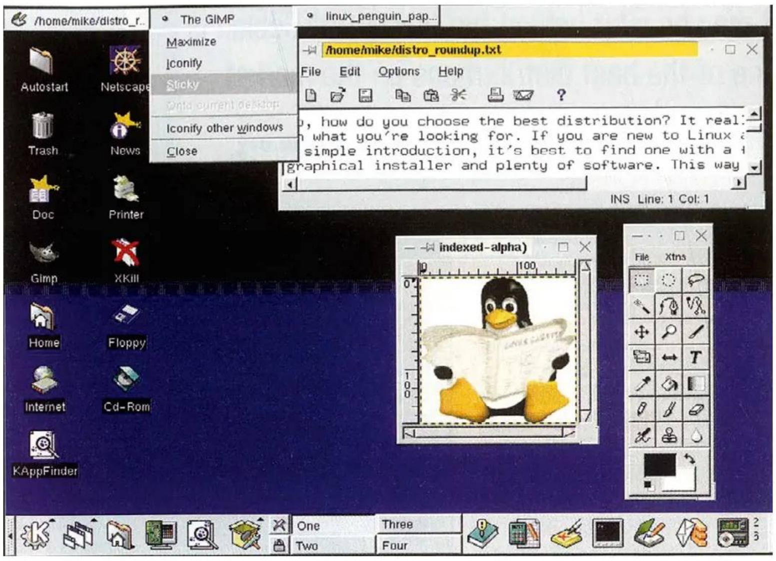
The concept behind Linux-Mandrake was originally born out of Red Hat's refusal to include KDE in its distribution. This was due to licensing concerns, so Mandrakesoft decided to create a variant of Red Hat with KDE included and ready to go. This meant new users wouldn't have to find and download the desktop suite from the web. Since then, Mandrake has evolved into a solid distribution in its own right. The new graphical installer is a fantastic, easy-to-use tool, and we had absolutely no problems getting underway with it.

A lot of thought has clearly been put in here: a column of lights down the side acts as a progress meter, while a bar of help text at the bottom provides tips for choices in each dialog box. You can choose a preset security level and even decide whether num-lock is activated at boot time.

Thankfully, a proper user account is created and PPP (dialup) configuration is done here, too. Apart from the long package installation process and lack of ability to configure sound, Mandrake's installer is the best graphical one we've seen and it's a joy for both newcomers and more experienced users alike.

In operation, the distribution still remains similar to Red Hat. However, one major enhancement lies in the hardware setup tool, *Lothar.* This automatically detected most of our hardware, although configuring it still proved to be difficult.

Still, it's certainly an impressive start, and with more development, it could really attract non-technical users to Linux. The *DrakConf* configuration tool will also be a help for newcomers and assists in a range of admin chores, while the Supermount feature, for automatic mounting of removable media, is a nice touch.


/home/mike/distro_r...
The GIMP
linux_penguin_pap...
Maximize
Iconify
Sticky
Onto current desktop
Iconify other windows
Close
Autostart
Netscape
Trash
News
Doc
Printer
Gimp
XKill
Home
Floppy
Internet
Cd-Rom
KAppFinder
/home/mike/distro_roundup.txt
File
Edit
Options
Help
INS Line: 1 Col: 1
indexed-alpha)
File
Xtns
One
Two
Three
Four

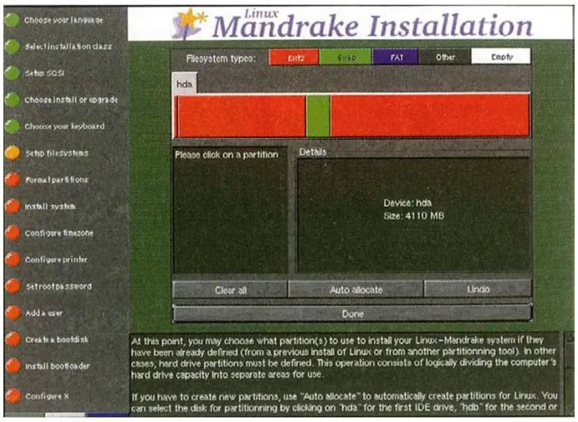
```
, how do you choose the best distribution? It real:
 what you're looking for. If you are new to Linux a
 simple introduction, it's best to find one with a 
graphical installer and plenty of software. This way
```

The excellent installer, with its powerful partitioning tool.

Devine desktop

On the desktop side, Mandrake has KDE 1.1.2 by default, and Gnome, *Window Maker, IceWM* and Enlightenment are included as well. Also on the CD are *Netscape, GIMP* and *Wine*, while *Emacs,* KDevelop and EGCS are available for developers. Mandrake's KDE setup is good and the on-disc documentation is thorough and well written. The range of apps on the CD is varied and up to date, and while it's doubtful how much effect the Pentium-class CPU optimisations have, the system feels snappy and responsive.

With all this in mind, and the brilliance of the *DrakX* installer, Mandrake is the best general-purpose distro available. New users will love the easy setup, ready-to-go KDE desktop and helpful documentation, while experienced Linuxers will be pleased with its variety of desktops, development tools and general flexibility. LXF


Choose your language
Select installation class
Setup SCSI
Choose install or upgrade
Choose your keyboard
Setup filesystems
Format partitions
Install system
Configure timezone
Configure printer
Set root password
Add a user
Create a bootdisk
Install bootloader
Configure X
Linux Mandrake Installation
Filesystem types:
Ext2
Swap
FAT
Other
Empty
hda
Please click on a partition
Details
Device: hda
Size: 4110 MB
Clear all
Auto allocate
Undo
Done

At this point, you may choose what partition(s) to use to install your Linux-Mandrake system if they have been already defined (from a previous install of Linux or from another partitionning tool). In other cases, hard drive partitions must be defined. This operation consists of logically dividing the computer's hard drive capacity into separate areas for use.

If you have to create new partitions, use "Auto allocate" to automatically create partitions for Linux. You can select the disk for partitionning by clicking on "hda" for the first IDE drive, "hdb" for the second or

Mandrake's desktop, KDE, as it appears at first boot.

VERDICT

DEVELOPER: Mandrakesoft
WEB: www.openmandriva.org
LICENCE: Various

FEATURES	9/10	**EASE OF USE**	9/10
PERFORMANCE	10/10	**SOFTWARE**	8/10

Easy to use, robust, fast and with lots of great software.

» Rating 10/10

Red Hat 7.3

Richard Drummond asks whether the biggest is necessarily the best as he examines the latest release.

IN BRIEF

From the August 2002 issue of **LXF30**. One of first commercial Linux distros and the one that helped propel Linux into every data centre in the world and establish a lucrative training ecosystem, too.

SPECS

Released: May 2002
CPU: 586 (Pentium)
Mem: 32MB (64MB GUI)
HDD: 650MB
Builds: x86

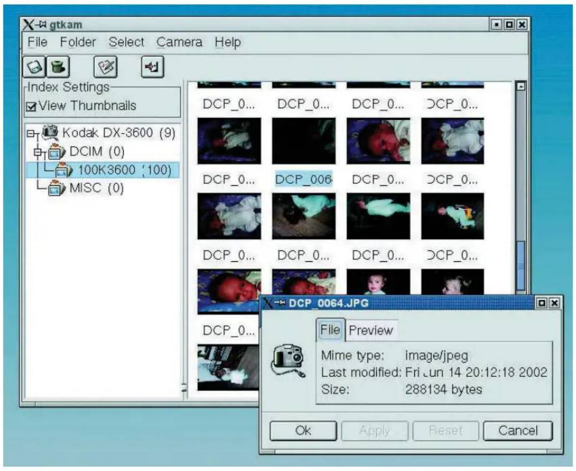
For many, Red Hat is synonymous with Linux, and the quality of its distros influences how Linux is perceived in the corporate world. Red Hat has a reputation for providing robust, well-tested distros with good support. Red Hat 7.3 continues this trend, offering dependable and compatible software, though it lacks significant innovation. While rivals like Mandrake and SUSE may provide a more integrated and comfortable desktop experience, Red Hat remains a popular choice for its reliability.

Red Hat 7.3 comes in Personal and Professional editions, which share the same core distribution. The Personal edition, reviewed here, is aimed at workstation users, while the Professional edition targets the server market. Both are available on seven CDs or as downloadable ISOs. The boxed Personal edition includes extras like a 30-day Red Hat Network membership, an installation manual, *StarOffice 5.2* and a bonus CD with proprietary apps, primarily evaluation software. A DVD is also included for easier installation.

Installation is relatively straightforward. The first disc can upgrade existing installations, perform network installs via NFS, or serve as a rescue disc. Users can choose between graphical or text-based installation. The GUI-based installer is mostly straightforward, though improvements to navigation, online help and keyboard shortcuts are needed. Red Hat's partition editor*, Disk Druid,* lacks non-destructive resizing tools – a notable omission. Disk management is otherwise flexible, with support for ext2, ext3, software RAID and LVM. Hardware detection is solid, though graphics card configuration can be confusing with multi-headed systems. Driver support is good, but some closed source drivers are not included.

Choosing software packages during installation can be tedious. Users select an installation class (Server, Workstation, Laptop or Custom), then choose task-orientated groups. Both Personal and Professional editions use the same installation CDs, so all server packages are available in the Personal edition. Package selection works well, but creating a stripped-down installation can be challenging. Dependencies are automatically checked, though can be overly strict.

Despite its flaws, the installer has commendable features. It uses the GRUB bootloader by default, which is more flexible than Lilo. Configuring the built-in firewall is simple, with options for high, medium or no security levels. Red Hat offers a choice between KDE 3.0 and Gnome as desktop environments. However, the KDE build is a vanilla version with little integration, and stability issues were noted due to the immaturity of KDE 3.0 at the time. Gnome software is available via a submenu, but finding other software can be difficult. Red Hat 7.3 includes a wealth of software, with a new focus on multimedia. However, the choice of office software is limited, with the older *StarOffice 5.2* being offered instead of the newer *StarOffice 6.0.*



Mime type: image/jpeg
Last modified: Fri Jun 14 20:12:18 2002
Size: 288134 bytes

Red Hat 7.3 includes multimedia software like Xine and GPhoto2.

System configuration tools are available from a central Control Panel, but finding the right tool can be confusing. Post-install configuration of X requires manual editing of the config file. Software updates are managed by *up2date*, which requires registration with the Red Hat Network. This is free for a demo-level subscription. *Up2date* manages updates but does not install new software and is more reliable than Mandrake's system. The Red Hat Network also offers comprehensive system management tools, which can be useful for sysadmins but less so for home users.

Red Hat 7.3 is a solid distro that fulfills most needs but lacks excitement. The Personal edition's target audience is unclear, as it doesn't offer much over competitors for desktop use, and the Professional edition exists for server use. The real selling point is the Red Hat Network's support and management tools. If only the software is needed, other distributions like Mandrake and SUSE may be better choices. LXF

VERDICT

DEVELOPER: Red Hat
WEB: www.redhat.com
LICENCE: Various

FEATURES	**8/10**	**EASE OF USE**	**8/10**
PERFORMANCE	**7/10**	**SOFTWARE**	**7/10**

Reliable, well-rounded but rather conservative distro. The up2date tool and Red Hat Network are a useful combination.

» Rating 7/10

Roundup

Elementary OS » Ubuntu » Deepin Linux » Linux Mint » Zorin OS » Lubuntu » Pop!_OS » MX Linux

Mayank Sharma has taken a well-deserved final rest from *HotPicks* but is now stuck here!

Windows user distros

If you're trying to get grandma off her old Windows laptop, **Mayank Sharma** might not be as old but he's certainly as cranky.

HOW WE TESTED...

We analysed various aspects of different Linux distros to find the best for Windows users. We looked at how resource-intensive the distros were, what kind of hardware they'd run on smoothly, the documentation and out-of-box experience. We considered installation time and the apps that came with the distro.

We evaluated the desktop environment based on the functionality, customisability and visuals. We also checked out the forums to see if there was an active community that could help with doubts.

With the best distro for Windows users, you'll enjoy a smooth transition to Linux. But you'll have to look at many factors before selecting the right distro for yourself.

Check whether your hardware can run the distro – not all distros run on 32-bit architecture. You'll want a lightweight distro if you have older hardware. It helps if there's lots of documentation and an active forum where you can seek help. Also, check out the desktop environment to see if it's to your liking.

CREDIT: Magictorch

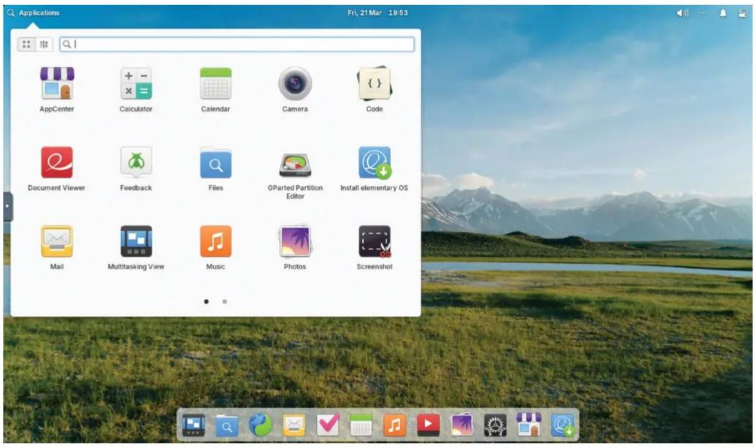
As a fond farewell, we're having a look at the best distros you can annoy your Window-using friends with. These include some of the best distributions out there. We're specifically looking at distros that make it simple and easy for Windows users to take the leap and try Linux without feeling overwhelmed.

It can be an intimidating experience, especially for people coming from proprietary operating systems like Windows. Thanks to their open source nature, Linux distros offer a lot more access than their closed source cousins, which makes the transition particularly difficult for many. This is where these specialised distros, designed for Windows users, come in. Their objective is to allow users to experience the goodness of Linux while minimising the learning curve that's associated with switching to a new OS. They all take steps to ensure the transition is as effortless as possible.

We've tested numerous Linux distros to find the best ones for Windows users. We looked at how user-friendly they are, the hardware requirements, the ease of installation, and the overall out-of-box experience. We also considered the distro's learning curve and the desktop environment, among other aspects.

Elementary OS

Best Ubuntu distro for Windows or Mac users.


Applications
Fri, 21 Mar 19:53
AppCenter
Calculator
Calendar
Camera
Code
Document Viewer
Feedback
Files
GParted Partition Editor
Install elementary OS
Mail
Multitasking View
Music
Photos
Screenshot

With a solid dose of Mac OS inspiration, the desktop is easy on the eye.

Elementary OS is based on Ubuntu. There are new releases every one to two years, each named after a different god. For instance, the most recent version (7.0) is code-named Horus.

This isn't all that's divine about this OS. It has made a name for itself for crafting a very usable and aesthetically pleasing desktop distro. Everything from its pre-installed apps to its home-brewed desktop is designed to give a comforting experience to people new to Linux.

Its custom-built Pantheon desktop is a pleasing aesthetic take on the classical desktop metaphor. One of its distinguishing features is the picture-in-picture mode that enables you to select an area of a window or the desktop, then pops it out. This pop-out is movable, resizable, always-on-top, and can move across workspaces.

The distro comes with a carefully pruned collection of pre-installed apps that's been assembled to make the desktop experience more consistent and appealing to new Linux users. In fact, many of its most-used pre-installed apps have functional names like *Mail, Music, Photos* and *Videos,* which makes them easier to discover.

The distro also has an onboarding app to help new users set up their installation. Elementary OS also uses its own *AppCenter*. The latest version emphasises app screenshots, as well as providing more information about the developer and how actively packages are maintained. Installation is via Flatpaks, so it's very easy to toggle automatic app updates, too. It takes a similar approach to system settings, with its custom app that exposes the bare essentials instead of throwing out an endless stream of toggles and switches.

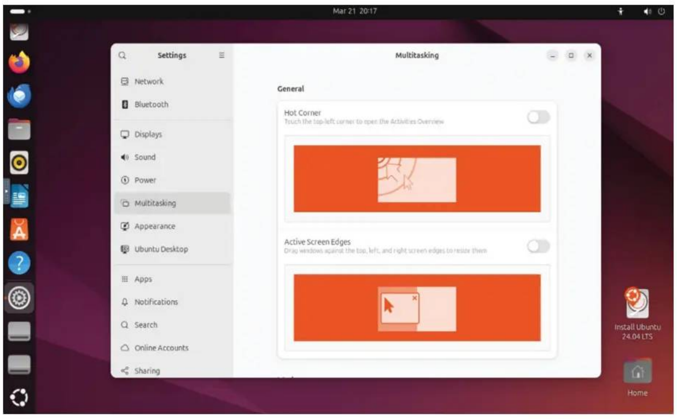
VERDICT

DEVELOPER: Elementary **WEB:** https://elementary.io
PRICE: Free or donation

+ Aesthetic desktop + Picture-in-picture mode
+ Custom apps + Support for Flatpaks
- Doesn't support 32-bit architecture

Ubuntu

Best Linux distro for Windows users that's easy to use.


Mar 21 20:17
Settings
Network
Bluetooth
Displays
Sound
Power
Multitasking
Appearance
Ubuntu Desktop
Apps
Notifications
Search
Online Accounts
Sharing
Multitasking
General
Hot Corner
Touch the top-left corner to open the Activities Overview
Active Screen Edges
Drag windows against the top, left, and right screen edges to resize them
Install Ubuntu 24.04 LTS
Home

Canonical has developed a tweaked version of the Gnome desktop.

Ubuntu is one of the most popular flavours of Linux and strongly recommended for Linux newbies, because it's extremely accessible. That's why we've already featured one variation of Ubuntu in this guide (and there are more to come), but it's worth considering the main Ubuntu release itself.

New versions of Ubuntu are released every six months, and every other year the developer Canonical releases an LTS (long-term support) version of Ubuntu. These guarantee five years of security and general maintenance updates, so you can carry on using your machine without the hassle of running a full upgrade every few months. Standard releases are supported for one year only.

The current LTS version of Ubuntu uses the Gnome desktop environment, which may be rather less unfamiliar to Windows and Mac OS users.

The good news is that Ubuntu is available in a variety of flavours. The Lubuntu OS uses the LXQt desktop environment. This will feel comfortable for Windows users, as you can access the menu and minimise windows just as before. Both the desktop and apps that come bundled with Lubuntu are designed to be lightweight, making it perfect for older machines.

As of version 23.04, Ubuntu now officially supports the Cinnamon desktop *(see Linux Mint p30)*. This has a similar look and feel to Windows but uses much richer graphics. Naturally, you'll need a more recent PC to make use of all its features.

Ubuntu has also become increasingly integrated with cloud computing services, making it not just a good distro for easing beginners into Linux, but also one for those looking to develop their long-term business IT skills.

VERDICT

DEVELOPER: Canonical **WEB:** www.ubuntu.com
PRICE: Free, donation, commercial

+ Very accessible for novices + Security and stability of LTS version
+ Lubuntu spin is great for underpowered PCs
- Some flavours heavy on resources

Deepin Linux

Best Debian distro for Windows users.

Deepin Linux is a Debian-based distro that's known for its aesthetically pleasing custom desktop environment called DDE. Together with several home-brewed apps, the distro is designed to ease new users into the Linux desktop.

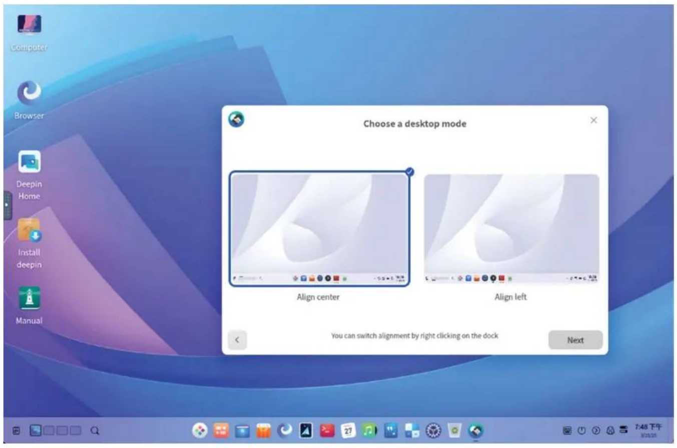
Deepin comes in both a stable and experimental version. The stable version (currently v23.1) is based on the unstable version of Debian at the time of release.

The experimental alpha version (currently v25) is designed for non-production environments. In other words, it's better for personal use rather than anything critical. The latest experimental build is visually very rich, with a so-called flow design and added widgets, so it closely resembles Windows 11.

Deepin uses a first-boot configurator app to help you tweak the look and feel of your installation by changing icons, enabling window effects and more. These are classified into two broad categories and you can use either, depending on the available resources on your computer.

On lower-end machines, you can run the installation in Efficient mode to make the best use of the limited resources, while on newer ones you can use the Fashion mode to turn up the bling. The customisations are quite diverse and extend from the main desktop area to the notification management.

There's a Deepin custom app for conducting the majority of common desktop tasks, such as watching films, listening to music, viewing images, taking backups, recording screencasts, and about a dozen more.



You can switch alignment by right clicking on the dock

As a Chinese backed distro, it's fended off privacy issues over the years.

The other custom app deserving a mention is the *App Store*. It makes it easy to discover and install new apps, which will be appreciated by users unfamiliar with the Linux app ecosystem. There's also an Uninstall section to help get rid of installed apps.

VERDICT

DEVELOPER: Wuhan Deepin Technology
WEB: www.deepin.org **PRICE:** Free

+ Home-brewed desktop + Helpful first-boot wizard
+ Touch-friendly interface – Slow installer

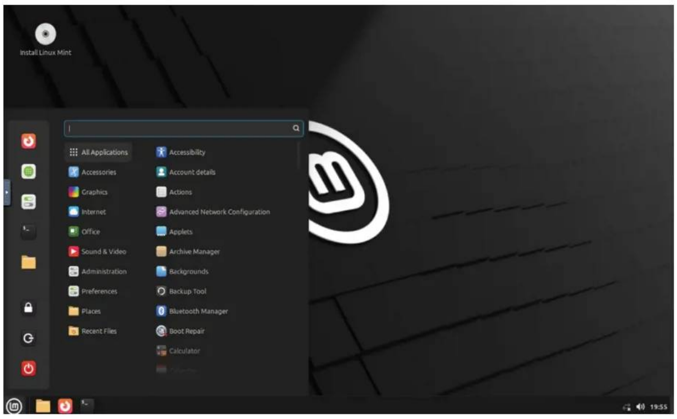
Linux Mint

Best unique distro for Windows users.

Linux Mint is based on Ubuntu and is specifically designed to work out of the box. The two main flavours use the MATE and Cinnamon desktop environments. The layout is familiar for Windows users, with a task bar and configurable menus on the bottom.

This distro emphasises compatibility with restricted or proprietary formats. Out of the box, it can edit *Microsoft Office* documents via *LibreOffice*. With one click of your mouse, you can also install multimedia codecs to play all kinds of audio or video files. You can also use its *Software Manager* to install more programs. Linux Mint has its own repositories but can also access Ubuntu's. There are around 30,000 packages available overall, so it's likely you can find a good equivalent to Windows apps.

Where many Ubuntu spin-offs stick with the Gnome display manager, as used by Ubuntu itself, Mint's default is Cinnamon. This started as an offshoot of Gnome 2 when version 3 was released. Version 3 was the first to drop support for the panel (task bar in Windows parlance) in favour of a purer shell, which likewise demoted widgets and jettisoned desktop icons. Cinnamon puts all of these front and centre, which is one of the reasons why it's often held up as ideal for anyone switching from Windows. It also has a Windows-like menu, with applications sorted into categories, and essential tools – such as the browser and settings – kept in view up the side. You can pin your most-used apps to the panel, so they're never more than a click away.



The in-house Cinnamon desktop is ideal for those after a classic workflow.

Linux Mint with Cinnamon is a pleasant place to spend a lot of time, and while we don't think Cinnamon feels as dynamic as Windows 11, its familiarity will likely be a significant draw for more cautious switchers (although they should also consider Zorin).

VERDICT

DEVELOPER: Linux Mint **WEB:** https://linuxmint.com
PRICE: Free, donation

+ Familiar GUI + Useful pre-installed apps
+ Support for Windows formats + Well-established dev team

Zorin OS

Best Linux distro for Windows users with older machines.

At first glance, Zorin OS comes off as just another Ubuntu-based distro. However, what makes it unique is the home-brewed *Zorin Appearance* app that tweaks the desktop environment to make it resemble Windows in both form and function.

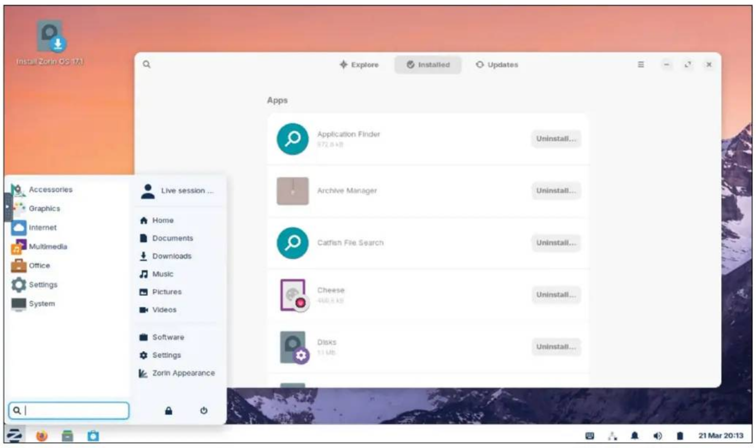
Pitched as a distro for first-time Linux users, Zorin is designed to appeal to users coming from popular proprietary OSes, namely Windows and Mac OS.

The GUI is Windows-like, with a menu that opens from the bottom-left of the desktop and a task bar. You can use the launch menu to install *Windows App Support* to run your favourite Windows apps through the *Wine* compatibility layer of *PlayOnLinux*. The pre-installed *LibreOffice* suite can also open *Microsoft Office* documents. There is a neat recent addition to this where it'll offer open source alternatives to known Windows apps to help ease users off Windows tools.

Zorin is available in three different versions – the Core and Education editions are free. The Core edition is the standard edition that includes all the apps you'd find in a normal desktop Linux distribution, there used to be a Lite edition for older systems but this is no longer supported and there's no 32-bit support any longer either.

The paid Pro version comes with support and a few extra features, such as the option of using interfaces that mimic Mac OS, classic Windows and Windows 11. It's also chock-full of all kinds of apps like advanced video and photo editors.

The distro is complemented by a useful selection of very clearly presented documentation, which is again written for users migrating from proprietary desktops and aren't used to the Linux way of doing things.


Install Zorin OS 17.1
Explore
Installed
Updates
Apps
Application Finder
Uninstall...
Archive Manager
Uninstall...
Catfish File Search
Uninstall...
Cheese
Uninstall...
Disks
Uninstall...
Accessories
Graphics
Internet
Multimedia
Office
Settings
System
Live session ...
Home
Documents
Downloads
Music
Pictures
Videos
Software
Settings
Zorin Appearance
21 Mar 20:13

There's nothing wrong with tuning your appeal to Window users.

VERDICT

DEVELOPER: Zorin Group **WEB:** https://zorin.com/os
PRICE: Free (£48 Pro)

+ Look-changer app + Two free editions + Useful documentation
- Official tech support isn't great

Lubuntu

Best lightweight Linux distro for older machines.

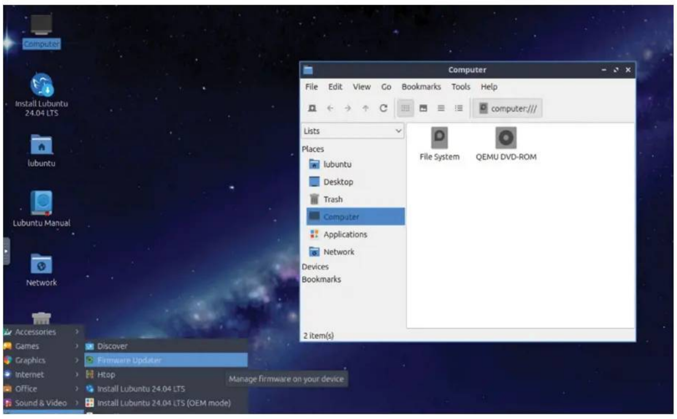
The 'L' in Lubuntu might as well stand for lightweight, as the distro unashamedly appeals to those Ubuntu users who are looking for an OS that requires fewer resources than most modern distros, but doesn't force you to compromise on your favourite apps.

Lubuntu is primarily designed for older machines. The default desktop is based on LXQt, which is far less resource-hungry than mainstream Ubuntu's Gnome 3 desktop. It comes with a selection of useful tools and utilities, including the latest Snap versions of *Mozilla Firefox, Featherpad* and *VLC Media Player.*

You can use Lubuntu's *Discover Software Center* to install more apps. Still, as a lightweight distro, Lubuntu focuses on being fast and energy efficient, which is why it comes with so few pre-installed programs. The most recent releases have even reverted to using *LibreOffice* rather than *Abiword* for word processing.

This doesn't mean that Lubuntu is lacking, though – it's based on the latest Ubuntu release, so it's a proper modern Linux distro – it's just shed all unnecessary weight, in the manner of a rally car having all but one of its seats removed.

The most recent releases of Lubuntu have increased the minimum required RAM to run the OS to 2GB. However, to ensure smooth running, try to use a machine with at least 4GB of RAM. It's now only available in 64-bit builds.


Computer
Install Lubuntu 24.04 LTS
lubuntu
Lubuntu Manual
Network
Computer
File
Edit
View
Go
Bookmarks
Tools
Help
computer:///
Lists
Places
lubuntu
Desktop
Trash
Computer
Applications
Network
Devices
Bookmarks
File System
QEMU DVD-ROM
2 item(s)
Accessories
Games
Graphics
Internet
Office
Sound & Video
Discover
Firmware Updater
Htop
Install Lubuntu 24.04 LTS
Install Lubuntu 24.04 LTS (OEM mode)
Manage firmware on your device

Built from the Ubuntu ecosystem, there's plenty of support.

One of the unique selling points of Lubuntu is its compatibility with Ubuntu repositories, offering access to thousands of packages, although the more you install, the less lightweight your distribution becomes. The minimalist LXQt environment is also very efficient, but if you have a high-performance machine, you may prefer a visually richer desktop, such as Gnome or KDE.

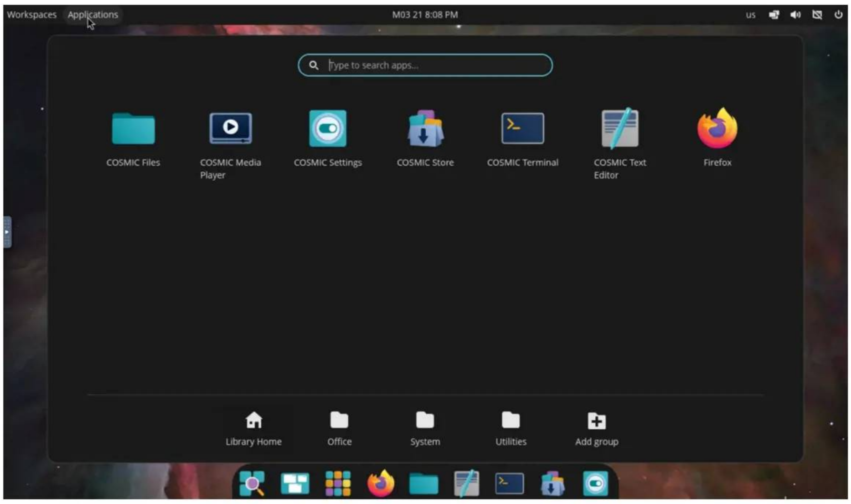
VERDICT

DEVELOPER: Lubuntu.me **WEB:** https://lubuntu.me
PRICE: Free

+ Ubuntu but slimmed downs. + Uses nifty lightweight apps.
+ Compatible with Ubuntu repositories. - Avoid for high-performance PCs

Pop!_OS

Best Linux distro for gaming.


Workspaces
Applications
M03 21 8:08 PM
us
Type to search apps...
COSMIC Files
COSMIC Media Player
COSMIC Settings
COSMIC Store
COSMIC Terminal
COSMIC Text Editor
Firefox
Library Home
Office
System
Utilities
Add group

Pop!_OS takes pride – and rightly so – in its cutting-edge desktop development.

Pop!_OS is developed and maintained by hardware vendor System76, and besides being shipped on its own hardware, is also available as a free download. The distro has several intriguing features, which make it an interesting option, especially for gamers and power users.

The distro is based on the Ubuntu LTS release (in this case 22.04) and sports its own user interface over Gnome, called Pop Shell.

While there are several other gaming distributions for Linux, what makes Pop!_OS unique is that it ships with all the necessary plumbing for gamers. For instance, its developers ensure that hybrid graphics work flawlessly on the platform.

If you have a hybrid graphics card, the distro gives you the option to launch games on the GPU in the context menu. You'll also be able to easily toggle between battery-saving and high-powered graphics.

There are a few other editions of Pop!_OS. Besides the standard edition, there is one that is designed specifically for users with Nvidia hardware and ships with the proprietary driver for the hardware. There's also a build for the Raspberry Pi 4. Pop!_OS also encrypts your installation by default, and while it ships with minimal apps, you can flesh out your installation using its custom intuitive app store, called *Pop!_Shop,* which in addition to the regular desktop applications, also includes the likes of *Steam, Lutris* and *GameHub.*

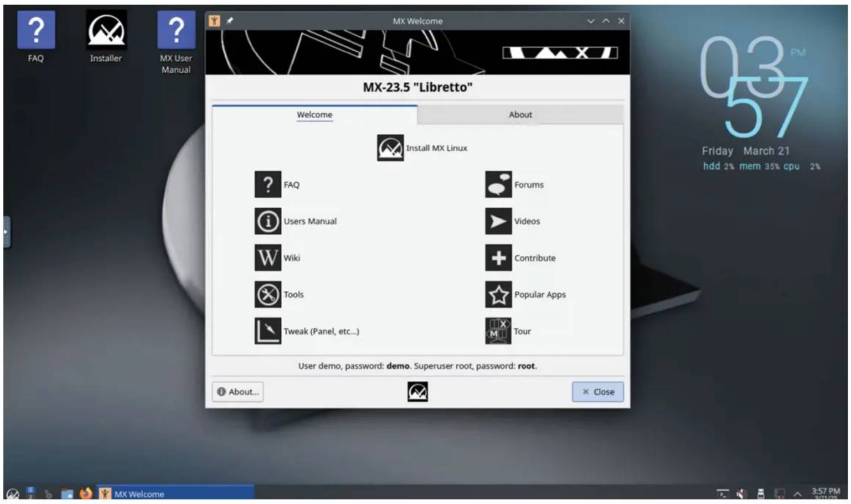
VERDICT

DEVELOPER: System76 **WEB:** https://system76.com/pop
PRICE: Free, donation

+ Hybrid graphics + Special image for Nvidia users
+ Keyboard navigation + Cutting-edge desktop
– Not the best for old hardware

MX Linux

Best distro for beginners with older hardware.


FAQ
Installer
MX User Manual
MX Welcome
MX-23.5 "Libretto"
Welcome
About
Install MX Linux
FAQ
Forums
Users Manual
Videos
Wiki
Contribute
Tools
Popular Apps
Tweak (Panel, etc...)
Tour
About...
Close
03
57
PM
Friday March 21
hdd 2% mem 35% cpu 2%
3:57 PM

User demo, password: **demo**. Superuser root, password: **root**.

Lacking the flash of modern desktops, it's far more useful.

Another distribution that sports an attractively tweaked Xfce desktop is MX Linux. The distro looks great and performs adequately, even on resource strapped machines.

MX Linux takes pride in its user-friendliness, which it achieves through a selection of custom utilities. The desktop boots to a welcome screen that contains useful links to common tweaks as well as its custom set of tools.

In terms of apps, it includes everything to fulfil the requirements of a typical desktop user, including a handful of games. MX is built on the current Debian Stable 12 release but includes updated versions of several apps and also backports newer versions from Debian Testing.

The custom MX Linux tools are all designed to assist users manage their installation. Some of the noteworthy ones are a snapshot tool for making bootable ISO images of the working installation and a remaster tool to create your own customised version of the distribution.

Package management is handled by a custom tool as well, which is again designed to take the pain out of discovering and installing apps. The distro takes a pragmatic view and offers several popular proprietary apps in the mix as well. You can also browse and install Flatpaks from the Flathub repository right from this utility as well.

VERDICT

DEVELOPER: MXLinux **WEB:** https://mxlinux.org
PRICE: Free

+ Attractive desktop + Slew of custom tools
+ Supports 32-bit architecture as well

The verdict

Distros for Windows users

It's testament to how far Linux distros have come that there's now an abundance of distros that we can happily recommend for Windows users. In fact, the main problem is trying to cut the list down to a manageable number. There's no doubt that Ubuntu remains a key starter distro, if for no other reason than there's top-notch support. However, this in itself can be an issue, as many solutions pertain to older releases, and recent updates to Wayland can be confusing, even for experienced users. That's more of a nitpick, and the **Askubuntu.com** site does at least make it clear how old answers are, although new users might not be aware of issues between different releases.

That's why we think Linux Mint remains our go-to distribution for Windows escapees. It retains those Ubuntu technical roots, as well has having its own large and active support community. The development team is also pro-active in keeping it easy to use – you can argue about Snap issues, but the Mint team's reasoning is that it's better for users not to have Snaps – with a desktop that has traditional functionality, which certainly puts it above Ubuntu.

If you have a modern PC, we certainly recommended having a good play with Pop!_OS, Again an Ubuntu-based release, System76 very much wants it to get the best out of its cutting-edge laptops and PCs. It expects a reasonable amount of GPU acceleration and display resolution, which means you'll want a decent specification laptop or desktop to use it. If you have one, it's the modern Linux desktop you've been hoping for.

Before we move on from this publishing coil, Elementary OS remains one of the earlier stabs at bringing a level of sophistication to the Linux desktop. It remains an outstanding project, which we've happily dipped into over the years, and like Linux Mint has struck out to create its own look and feel for its apps.

Some of the big core distros aren't here: Arch, Fedora, OpenSUSE, Debian, Manjaro and Mageia. Some because they're not as novice–focused – Arch, Debian and Fedora, for example – but others because we simply didn't have room. The Linux desktop always has been and remains a vibrant, exciting and fabulous workspace, so get out there and enjoy it!

Linux Mint 22.1

Developer: Linux Mint
Web: https://linuxmint.com Price: Free, donation
Best unique distro for Windows users.

Elementary OS 8.01

Developer: Elementary
Web: https://elementary.io Price: Free or donation
Best Ubuntu distro for Windows users.

Ubuntu 25.04

Developer: Canonical
Web: www.ubuntu.com Price: Free, donation, commercial
Best Linux distro for Windows users that's easy to use.

Pop!_OS 24.04 a5

Developer: System76
Web: https://system76.com/pop Price: Free, donation
Best Linux distro for gaming.

Zorin OS 17.2

Developer: Zorin Group
Web: https://zorin.com/os Price: Free (£48 Pro)
Best Linux distro for Windows users with older machines.

Deepin Linux 25

Developer: Wuhan Deepin Technology
Web: www.deepin.org Price: Free
Best Debian distro for Windows users.

MX Linux 23.5

Developer: MXLinux
Web: https://mxlinux.org Price: Free
Best Linux distro for beginners with older hardware.

Lubuntu 25.04

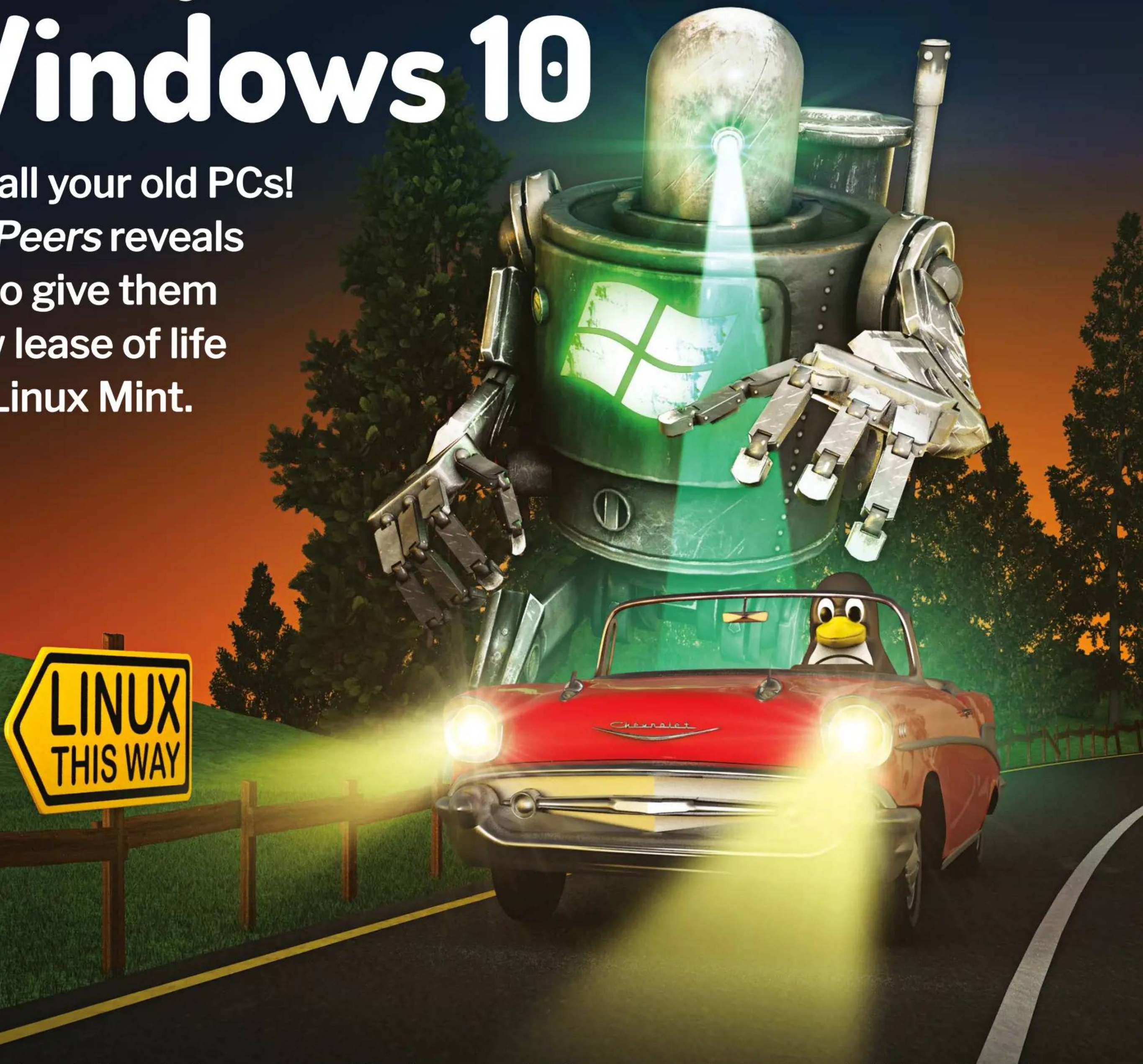
Developer: Lubuntu.me
Web: https://lubuntu.me Price: Free
Best lightweight Linux distro for older machines.

» ALSO CONSIDER

There are some obvious candidates missing from our main list and it's not because there's anything wrong with them. We certainly recommend Manjaro (**https://manjaro.org**) and the Arch-based distros, and there's a lot of chatter around CachyOS (**https://cachyos.org**), which people seem to like for cutting-edge gaming. We do feel, though, that we've neglected lightweight options for older hardware. We suggest Bodhi Linux (**www.bodhilinux.com**) because its one of the few distros that still support a 32-bit legacy build. Not that it's alone in that – we would also call out BunsenLabs (**www.bunsenlabs.org**) as another excellent lightweight Linux distro for older hardware. And, of course, as the name suggests, there's Linux Light (**www.linuxliteos.com**), for which we've been giving glowing reviews of late. LXF

Escape Windows 10

Save all your old PCs! *Nick Peers* reveals how to give them a new lease of life with Linux Mint.



You've probably received at least one email telling you that the end is nigh for Windows 10. Microsoft wants you to buy a new PC and upgrade to its privacy busting Windows 11, packed with intrusive tracking, unwanted AI and a host of other unwelcome features. It's tantamount to putting a gun to your head and saying, "Upgrade – or else!"

But what if we showed you another way? One that doesn't just mean you get to keep your PC, but also enjoy a significant performance boost – all within an environment that's familiar and easy to master? If you're not aware, let's just say one word: Linux. This isn't 2005 – Linux is powerful, user-friendly and popular. It's still open source, which means there's no ads or tracking. It offers a variety of distributions and desktops, enabling you to choose the perfect version for your needs. And you don't need a degree in computer engineering to use it.

We're going to introduce you to one of the most popular Linux distros of all: Linux Mint. Mint is perfect for most people because its default desktop environment – Cinnamon – feels familiar to anyone who's used Windows 10. It's easy to navigate, and armed with this guide, you'll not only wave goodbye to Windows 10 without so much as a backwards glance (other than to transfer all your personal files across), but you'll be taken on a tour of how it – and Linux – works, giving you the basics you need to start using your new OS. You'll find out where to find the apps you need, how to put a fail-safe backup in place so you can't go wrong, plus set it all up to your tastes.

So, wave goodbye to spamming, unwanted advertising and frequent nags to pay for an upgrade. Welcome to the world of Linux, with a side of Mint.

CREDIT: Magictorch

Prepare your old PC

Use this opportunity to invest in some inexpensive hardware upgrades before installing Linux.

Any PC capable of running Windows 10 (or even earlier) should be able to run Linux. In fact, the mere act of switching your computer to Linux Mint is going to give it a performance bump. That said, if you've been getting by with 4GB of RAM, now would be a good time to investigate at least doubling that amount – use a website such as **http://uk.crucial.com/upgrades** to determine what RAM you need, or use a tool like *HWiNFO* (**www.hwinfo.com**) to identify your current memory modules (look under Motherboard on the System Summary screen). A DDR4-2400 8GB stick of RAM costs as little as £15, for example.

As Windows 10 support is coming to an end, we're going to assume you have no plans to continue using it on your PC. If the idea of running Linux Mint alongside Windows 10 is more appealing, you need to explore setting up a dual-boot system – we covered this in last month's feature on installing Ubuntu 25.04. In this feature, however, we're waving goodbye to Windows and setting up Mint as your PC's only operating system.

Upgrade your drive

This begs the question of what happens to your Windows installation (and all the files on it). Rather than wipe the drive clean, why not use this as an excuse to replace the drive – a good idea if your existing hard drive is at least five years old. You can give your new Linux install a boost by investing in a fast SSD hard drive. These 2.5-inch SATA drives are designed to slot seamlessly in place of any existing boot drive, including ancient 3.5-inch models with spinning platters that take an age to boot and load software.

If there's a spare slot (and a spare SATA power plug from your PSU and SATA port on the motherboard), you can fit your new boot drive alongside your existing drive, which enables you to keep that old drive as a fail-safe (or as a backup drive) once you've copied your personal files from it to your new Linux installation. If there isn't room for another drive – perhaps you're switching to Mint on a laptop – you'll simply have to swap out your old drive for new when the time comes.

Like adding RAM, investing in a new SATA SSD drive isn't going to break the bank – you can pick up a spacious Crucial BX500 drive for around £30 (500GB) to £50 (1TB) depending on your storage needs.

Reuse your old drive

If you're unable to fit your new drive alongside the old one (very likely the situation with laptops), you need to ensure you can retain access to the old drive after installing Linux, so you can copy your personal data across. The simplest option here is to invest in a USB 3.0 drive enclosure for your old drive – 2.5-inch enclosures can be had for under £10 on eBay, while 3.5-inch enclosures for older drives tend to cost from £15 upwards, for example. Your Linux Mint installation will be able to read your Windows-formatted drive easily, making it easy to copy files off the drive or simply access them as and when you need them.

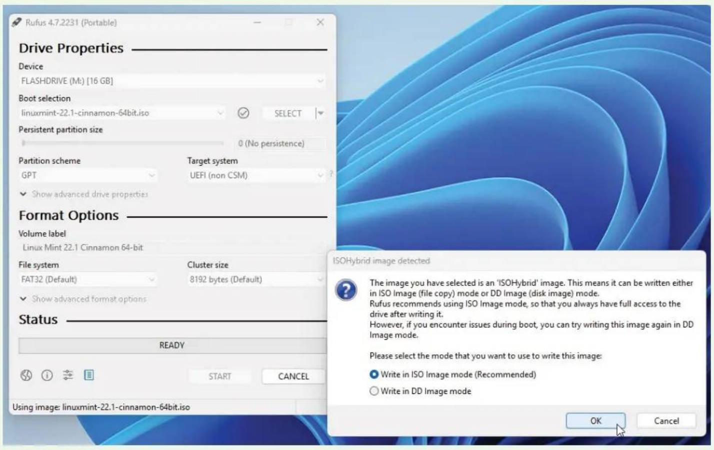
» CREATE BOOTABLE INSTALLATION MEDIA

To install any flavour of Linux on your system, you need either a spare USB flash drive (4GB for Linux Mint Cinnamon Edition) or blank DVD. Each Linux distro is delivered as a single ISO file, which can be burned to disc directly in Windows itself (right-click the ISO file and choose Burn Disc Image) or copied to a blank USB flash drive with the help of third-party software. Go to **https://linuxmint.com/download.php** to download Linux Mint Cinnamon Edition.

If you plan to go with the latter option – USB flash drives boot Linux far quicker than DVDs – download the portable version of *Rufus* (**https://rufus.ie/en/**). Once launched, click Yes twice when prompted, then select your USB flash drive from the Device drop-down menu. Click the Select button to the right of Disk Or ISO Image (Please Select) to locate and select your download Mint ISO file.

Change the partition scheme to GPT – the target system should change to UEFI (Non CSM). All other settings can be left as they are. Click Start, leave ISO selected as the write mode when prompted, and click OK again. Review the final warning and click OK. Once the drive has been created, click Close.

If you want to test multiple Linux distros, check out *Ventoy* (**www.ventoy.net**) instead of *Rufus*. This makes it easy to boot multiple distros from a single flash drive (make sure the drive is large enough – each ISO usually takes up 4-8GB of data, so a 64GB flash drive is a comfortable minimum for five or more distros). Once *Ventoy* is installed to your flash drive, simply copy ISO files to the drive – you can then choose which one to try when booting from the drive.


Rufus 4.7.2231 (Portable)
Drive Properties
SELECT
Show advanced drive properties
Format Options
Show advanced format options
Status
READY
START
CANCEL
OK
Cancel

Device: FLASHDRIVE (M:) [16 GB]
Boot selection: linuxmint-22.1-cinnamon-64bit.iso
Persistent partition size: 0 (No persistence)
Partition scheme: GPT
Target system: UEFI (non CSM)
Volume label: Linux Mint 22.1 Cinnamon 64-bit
File system: FAT32 (Default)
Cluster size: 8192 bytes (Default)
Using image: linuxmint-22.1-cinnamon-64bit.iso

ISOHybrid image detected

The image you have selected is an 'ISOHybrid' image. This means it can be written either in ISO Image (file copy) mode or DD Image (disk image) mode.
Rufus recommends using ISO Image mode, so that you always have full access to the drive after writing it.
However, if you encounter issues during boot, you can try writing this image again in DD Image mode.

Please select the mode that you want to use to write this image:

● Write in ISO Image mode (Recommended)
○ Write in DD Image mode

Rufus enables you to convert your flash drive into any bootable Linux installation when paired with the right ISO file.

Installing Linux Mint

Your hardware upgrades have arrived, and you're ready to go. Let's make the switch to Linux Mint.

After fitting your new RAM, boot into Windows to verify your memory has been recognised – right-click the Start button and choose System to check the installed amount matches what's in your PC. Once done, you're ready to test-drive Linux.

Reboot your PC with your flash drive or DVD inserted. If your PC is set up to boot from DVD or USB first, you should find yourself at the GRUB menu. If not, you need to either manually choose to boot from USB (look for an option to select the boot device at startup) or enter the BIOS/UEFI to override the boot choice or manually change the boot device order.

If you encounter an error message attempting to boot from the flash media, it may indicate that your PC's BIOS/UEFI is configured for legacy boot only. If so, navigate to the Boot section and look for a Boot Mode setting. This needs to be changed to UEFI only or, if the option exists, a hybrid mode like LEGACY+UEFI or UEFI with CSM. Choose the latter to allow you to continue using your existing Windows installation for now.

Test booting

Once your PC is configured to boot from your Linux media, the GRUB boot menu should appear. Leave Start Linux Mint selected and press Enter. After a short pause you'll see the Linux Mint logo appear, then you should wait for the Linux live environment to boot.

You end up at the Linux Mint Cinnamon desktop. This is a fully functioning Linux live environment that's self-contained on your Linux boot media – no files are written to hard disk. You can use it to explore the Cinnamon desktop following the guide over the page – it works the same way as a full-blown installation but any changes you make are lost when you reboot.

The live environment is a great way to familiarise yourself with the desktop, explore how Linux works and decide if you're comfortable with this desktop environment. If you want to dive deeper into Mint before installing it, check the box *(opposite)* for how to run a full-blown installation in a virtual environment.

And what if you find you don't like Mint's Cinnamon desktop? No problem, when you downloaded it, you'll have seen two other flavours were available: Xfce and MATE. Both offer a slightly different desktop environment, so why not give one or other a go?

If you're still unimpressed, don't worry – we've rounded up seven alternatives to Mint that make great Windows replacements. Check them out on *page 28.*

Fit a new drive

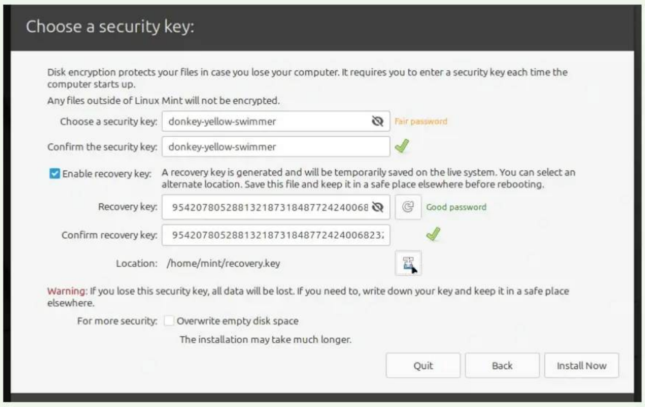
Once you're happy with your choice of distro, it's time to get your new hard drive fitted and installed. Shut down your PC and – taking suitable precautions – fit the new internal drive. If you're keeping your old Windows drive installed, unplug one of the data or power cables from the back temporarily – we don't want it interfering with the boot process. You'll be able to reconnect it once Linux Mint is in place. If not, now's

» ENCRYPT YOUR HARD DRIVE

If you're installing Linux Mint on an insecure computer – such as a laptop or a desktop that's left in a non-secure environment – you may wish to take additional steps to protect your PC and its data. To do so, when you come to install Linux Mint, be sure to click Advanced Features at the Installation Type screen. Select Use LVM With The New Linux Mint Installation and tick Encrypt The New Linux Mint Installation For Security.

After clicking OK followed by Continue, you are prompted to choose a security key, which is basically a strong password or passphrase that you'll need to enter each time you boot your computer going forward. The usual rules apply: the longer and more random the better, but given you'll need to remember this every time you switch on your PC, you may want to simply opt for longer and go for a three-word passphrase comprising three unrelated words such as correct-horse-battery-staple.

You're given the opportunity to create a recovery key – ticking this generates a long numerical code that you need to store somewhere safe (such as a password manager) or by creating a recovery key. Click the button next to Location to choose a permanent place, like a USB flash drive.


Choose a security key:

Disk encryption protects your files in case you lose your computer. It requires you to enter a security key each time the computer starts up.

Any files outside of Linux Mint will not be encrypted.

Choose a security key: donkey-yellow-swimmer Fair password

Confirm the security key: donkey-yellow-swimmer ✓

☑ Enable recovery key: A recovery key is generated and will be temporarily saved on the live system. You can select an alternate location. Save this file and keep it in a safe place elsewhere before rebooting.

Recovery key: 954207805288132187318487724240068 Good password

Confirm recovery key: 95420780528813218731848772424006823 ✓

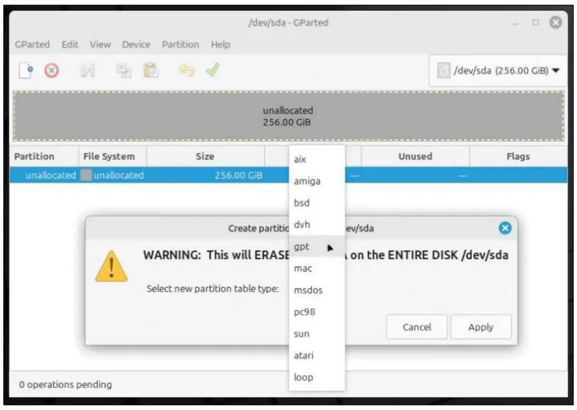
Location: /home/mint/recovery.key

Warning: If you lose this security key, all data will be lost. If you need to, write down your key and keep it in a safe place elsewhere.

For more security: ☐ Overwrite empty disk space

The installation may take much longer.

You can encrypt your hard drive with a strong security key, but it's not mandatory if your PC is somewhere secure.


/dev/sda - GParted
GParted Edit View Device Partition Help
/dev/sda (256.00 GiB)
unallocated
256.00 GiB
Partition
File System
Size
Unused
Flags
unallocated
unallocated
256.00 GiB
Create partiti
ev/sda
aix
amiga
bsd
dvh
gpt
mac
msdos
pc98
sun
atari
loop
Cancel
Apply

WARNING: This will ERASE … on the ENTIRE DISK /dev/sda

Select new partition table type:

0 operations pending

Don't forget to initialise your new hard drive by creating a GPT partition table. It's a simple task with GParted.

the time to fit your old drive into the USB caddy you bought for it, so you can access it going forward.

Once your new drive is fitted, start up your PC again. If necessary, perform the same steps as before to boot from your Linux media. Again, leave Start Linux Mint selected and press Enter when the GRUB menu appears, then wait for the live environment to boot.

Set up a drive

Now you need to set up your new drive for Linux. Click the LM logo in the bottom-left to reveal a Start menu. Roll your mouse over the Administration submenu to reveal a selection of apps – choose *GParted* to open Linux's powerful partition editor.

As you've disconnected your old Windows drive, there should be only one drive visible – represented by a grey block marked Unallocated, indicating the drive is empty. Open the Device menu and choose Create Partition Table. By default, MSDOS is selected as the partition table type, so click the drop-down menu and choose GPT, then click Apply. The drive is still marked as unallocated, but the partition table can be confirmed by choosing View > Device Information. Close *GParted*.

Install Linux Mint

We're now ready to install Mint properly to your new hard drive. Double-click the Install Linux Mint disc icon in the top-left. Work your way through the wizard. Confirm your language and keyboard, then tick Install Multimedia Codecs, before clicking Continue. As this is a brand-new installation on your freshly installed drive you can leave Erase Disk And Install Linux Mint selected and click Continue. If you're worried about the security of the data on your drive, check out the box *(left)* to find out how to encrypt your hard drive.

Verify your new drive is selected – **/dev/sda** in single-drive systems or pick the correct drive from the drop-down menu if you have more than one hard drive. If in doubt, re-open *GParted* alongside the installer and double-check which drive is empty. Once you're happy with your choice, click Install Now. You're prompted to write the proposed changes to disk – basically two partitions: ESP is your new boot partition, while the ext4 partition is your Linux system disk. Click Continue.

Set up your user account

Verify the correct time zone has been selected, then comes the most involved part of the process. Start by entering your name – your PC is automatically given a name based on this as well as the computer's physical name. This is used to identify your PC on your local network, so change it as you see fit.

You also need to secure your account with a password – you're prompted for this frequently going forward (Linux is a lot more secure than Windows), so while it should be strong, make sure it's memorable. You can afford to be relatively lax if you're setting up a desktop in a secure location like your home, but if you're installing Mint on a laptop, you may want to be more careful, even if you've encrypted the drive.

Once you click Continue, you're whisked to a progress screen where you'll see that files are already in the process of being copied to your drive. Grab a cup of tea and watch the slideshow that accompanies the installer, revealing some of the features and apps that come preinstalled with your new operating system.

When everything's complete, you have the option of continuing to test Linux Mint in the live environment, but where's the fun in that? Click Restart Now and wait to be prompted to remove the installation medium (your flash drive or DVD). Once done, press Enter and turn the page to start using your new OS.

QUICK TIP

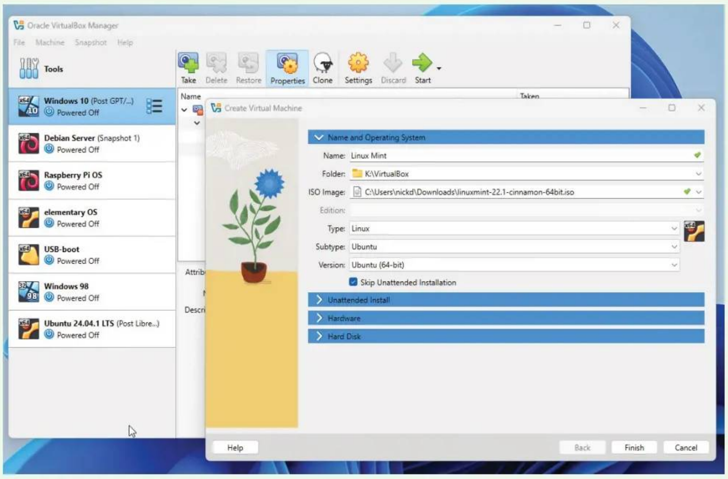
While Linux distros can read Windows NTFS and FAT file systems, it's best not to do this on a day-to-day basis. Linux files use extra data points for security that cannot be stored on NTFS drives, which long term can cause user headaches.

ROAD-TEST LINUX MINT FOR LONGER

While you can get an idea for how Linux Mint (or any distro) works from its live environment, none of the changes you make – from installing new software to tweaking settings – survive a reboot. So, you may feel like you need some kind of halfway house environment – once that lets you explore Linux over time through several reboots.

The solution is to install Linux in a virtual environment, which basically replicates the experience of using Linux inside a window on your PC's desktop. Head to **www.virtualbox.org** to download the free version of *VirtualBox*. Once installed, open the program and choose Machine > New to set up a virtual machine. Type `Linux Mint` and you'll see the machine type set to Linux > Ubuntu. Click the down arrow next to ISO File and choose Other to select your Mint ISO file.

Tick Skip Unattended Install, then work through the other sections if required before clicking Finish. Once your machine is created, it appears in the machine list – select it and click Start to begin your in-depth exploration of Linux, all without leaving the comfort of your Windows desktop.


Oracle VirtualBox Manager
File Machine Snapshot Help
Tools
Take
Delete
Restore
Properties
Clone
Settings
Discard
Start
Windows 10 (Post GPT/...)
Powered Off
Debian Server (Snapshot 1)
Powered Off
Raspberry Pi OS
Powered Off
elementary OS
Powered Off
USB-boot
Powered Off
Windows 98
Powered Off
Ubuntu 24.04.1 LTS (Post Libre...)
Powered Off
Create Virtual Machine
Name and Operating System
Unattended Install
Hardware
Hard Disk
Help
Back
Finish
Cancel

Name: Linux Mint
Folder: K:\VirtualBox
ISO Image: C:\Users\nickd\Downloads\linuxmint-22.1-cinnamon-64bit.iso
Edition:
Type: Linux
Subtype: Ubuntu
Version: Ubuntu (64-bit)
☑ Skip Unattended Installation

If you're not quite ready to commit to Mint, but want a more in-depth experience, try running it through VirtualBox in Windows.

Explore Linux Mint

You've installed Mint, and now it's time to set up and explore your PC's new, improved operating system.

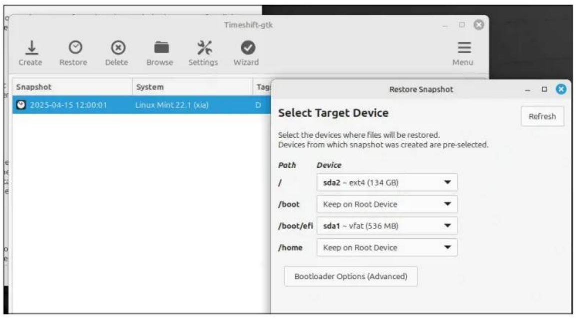
After you've completed the installation process and rebooted for the first time, you're either taken to the Mint login screen or – if you chose to encrypt your drive – you're first prompted to enter the passphrase you set in order to unlock the drive.

Once you reach the login screen, it's pretty standard fare. You'll see your username and a prompt to enter your password. You'll also see the menu bar at the top of the screen, where you'll find options in the top-right to set up accessibility options, change keyboard layout or quit Mint by restarting or shutting down your PC.

After entering your password and pressing Enter, you'll see your Mint desktop, complete with Welcome wizard. It's a good idea to work your way through this.

Pay attention to the System Snapshots section. This is Mint's equivalent of *System Restore,* called *Timeshift.* Clicking Launch also introduces you to a dialog you'll encounter frequently – a prompt for your password. Any action that requires administrative privileges – like in Windows – delivers this prompt; unlike Windows, however, you need to explicitly give your permission by entering your password before clicking Authenticate.

The *Timeshift* wizard opens – leave RSYNC selected and click Next. Wait while the wizard completes its assessment, then you're prompted to select a snapshot location. You can only back up to Linux-formatted filesystems, so even if your Windows drive is in the list, you can't select it. In the absence of a second drive (for now), choose your current partition and click Next.



2025-04-15 12:00:01 Linux Mint 22.1 (xia) D

Select Target Device

Select the devices where files will be restored.
Devices from which snapshot was created are pre-selected.

Path	Device
/	**sda2** ~ ext4 (134 GB)
/boot	Keep on Root Device
/boot/efi	**sda1** ~ vfat (536 MB)
/home	Keep on Root Device

Mint ships with two backup apps – Backup Tool covers your personal home directory, while Timeshift provides a system rollback tool.

You're then prompted to set your snapshot levels – snapshots are incremental, so each snapshot only records changes made to the filesystem since the last snapshot was taken to minimise drive use. So, set whatever schedule you like – if in doubt, the default settings will do, so tick all the boxes and click Next.

The next screen reveals that user directories (root user and your own user account) are excluded from the backup. Many apps store configuration information in hidden files, so we recommend ticking Include Only Hidden Files for your own account and Include All Files for the root account to cover these areas before clicking Next followed by Finish. Click Create.

» TROUBLESHOOT BOOT PROBLEMS

When you run into trouble loading Linux – it crashes, gets stuck displaying a flashing cursor or hangs with the Mint logo on screen – restarting your PC should bring up the GRUB boot menu. You can also try to bring this up manually by holding Shift as your PC boots.

You'll see two options: you can try to boot as normal by leaving Linux Mint 22.1 Cinnamon selected and pressing Enter, or you can select Advanced Options For Linux. Selecting this gives you the chance to load Mint in recovery mode or choose an earlier version of the underlying kernel if it exists. If you select recovery mode, you don't boot into the graphical environment, but see a rapidly scrolling list of messages before finding yourself at the Recovery menu.

You have several options – use *Clean* if you think the hard drive is full (confirm this from the system summary page), *dpkg* to attempt to repair broken packages, and *fsck* to perform a disk check. This last option often bears fruit. There's also an option to drop the root shell prompt, so you can interact directly with the underlying shell.

If none of these options work, follow the *Restore Your System* section of the main text to try to recover using a *Timeshift* backup.

Restore your system

Taking the time to set up *Timeshift* gives you peace of mind, as it makes it easy to undo future missteps. Whether you need to roll back to fix a problem or to undo something you regret, you have two approaches. If you're able to get into the Linux desktop as normal, open *Timeshift* from the Linux Mint Start menu (look under Administration). Select which backup to revert to, click Restore, follow the prompts and reboot once done.

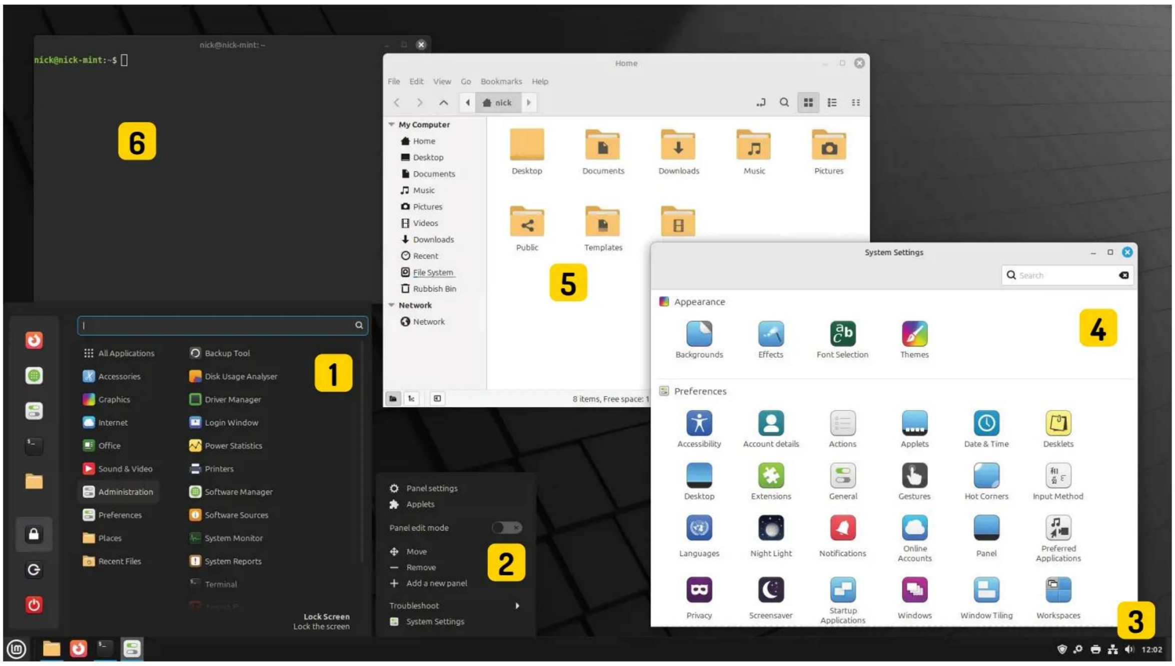
If you can't log into the desktop, use your Linux installation media to boot to Mint's live environment. From here, open *Timeshift* from the Administration section of the Mint menu. Click Next, then select the partition containing your backup (if the drive's encrypted, you're prompted for the passphrase). Once selected, click Finish and you can restore your system.

Complete welcome wizard

The rest of the wizard is straightforward – check for recommended drivers, and open *Update Manager* to learn how Mint's updating system works. Follow the prompts, updating *Update Manager* if prompted and switching to a local mirror to speed up downloads. In future, keep an eye on the system tray for a shield with a red dot; this indicates updates are available. Clicking it opens *Update Manager* to apply those updates for you.

You're also prompted to open *System Settings* – Mint's equivalent of Windows 10's Settings dialog. Take

The Cinnamon desktop in a nutshell



```
nick@nick-mint:~$
```

1 Menu Mint's equivalent of the Start menu – you'll see handy shortcuts to key areas on the left, plus a searchable list of apps and settings in the main pane.

2 Panel This is Mint's taskbar – and you can configure it with more than just favourite shortcuts. Right-click to customise it, add new applets, and create additional panels.

3 System tray This is just an extension of the panel, designed to feel instantly familiar to Windows users in particular. You can customise it to suit your preferences, just as you would with any other part of the panel.

4 System settings Mint's Settings tool organises everything into four distinct sections with logical names – just click one to open it.

5 Files This gives you easy access to your Home folder and other parts of your system. You'll find little here to surprise you after using the Windows File Explorer.

6 Terminal Access Linux's underlying interface, the shell, from here. It's not as scary as it looks, and is often the quickest way to get things done.

the time to explore this – it's a series of buttons divided into four categories: Appearance, Preferences, Hardware and Administration. It's all relatively straightforward, but once you've mastered the basics of navigating your desktop, explore ways to customise it further with Desklets (the equivalent of Windows' desktop widgets), Applets (tools you can add to the Cinnamon panel), Actions (extra options for the right-click menu) and Extensions (more added functionality).

Find and install new apps

Below this is a shortcut to the *Software Manager,* the easiest way to add apps. Linux lets you run apps from a variety of sources: collections known as repositories, specialist hubs such as Flatpak and Snap, standalone installation files (DEB) and portable images (AppImage).

We'll cover some of these in more detail over the page, but let's focus on *Software Manager.* Here, you can install programs held in Mint's own repositories as well as the Flatpak hub. When the main screen opens, you're greeted with a list of recommended applications, plus categories you can browse. There's also a search bar at the top if you know the app you want to install.

When you select an app, you're whisked off to its own page with description, screenshots and reviews. The Details panel also provides details of the version being installed, along with its size. In the top-right are two buttons: an Install button and a drop-down saying one of System Package or Flatpak (Flathub). Many packages are available through both sources, so what's the difference? Typically, Flatpak releases are up to date, whereas system packages become outdated over time as they're frozen at the point of Mint's last major release. System packages are also much smaller, while Flatpak versions can take up gigabytes of space. We'll explain why over the page, but if you have the drive space to spare and want the latest version of a package (such as *GIMP 3.0* over *2.10),* Flatpak is the way to go.

Tighten security

The final step in the wizard is to enable the built-in firewall, which you can also access through *System Settings.* It's a simple setup and works in a similar way to the Windows firewall – by default, all outgoing traffic from apps and services to the internet is allowed, while all traffic to your computer from outside is disabled.

If you want to allow inbound traffic, switch to the Rules tab and click + to open the Add A Firewall Rule dialog. There's a Preconfigured tab for common apps and services, or you can switch to Simple or Advanced to manually set things up if you have experience setting up similar rules in Windows. In virtually all cases, you're prompted to verify your router is set up to forward traffic to your PC (log into its admin console through a browser and set up rules manually if uPnP is disabled).

You'll notice there's no built-in antivirus software for Linux – it's not required for home Linux installations. Now you've set up your new Mint installation and had a poke around, turn the page to discover what you need to learn going forward.

»

Master Linux Mint life

Your new OS is up and running, so it's time to complete the job and discover what you need to know going forward.

QUICK TIP

Get our old terminal guides from: https://bit.ly/lxf_terminal, or Mayank Sharma's Master the Terminal feature from https://bit.ly/lxf222_feat.

As things stand, you've set up Mint and had a small nose around the desktop. You may have even installed an app or two. So, what's next on the to-do list? First, if you have data you need to access on your old Windows drive, now's the time to copy it across to your new installation. If necessary, shut down your PC, open your case and reattach the drive cable; otherwise, connect the drive in its enclosure to a spare USB 3 port on your PC.

Once done, open the *Files* app, where you're greeted with an environment similar to File Explorer in Windows 10. You're placed at your personal **Home** folder, where you'll see familiar-looking folders such as **Documents**, **Pictures** and **Videos** are ready and waiting to receive all your personal data. Press Ctrl+N to open a new *Files* window, then examine the left-hand pane for a Devices section. If necessary, click to expand this, where you should see your old Windows system drive is listed, either with its volume name or its drive size. Click this and you'll see the familiar folders from your old Windows 10 installation. Copying files from here can be done simply by dragging from one window to the other – you'll find all your old personal files under **Users\username** on your old Windows drive.

Link to network shares

Files is incredibly easy to use, so we won't waste time on any other functions apart from connecting to any network shares you might have. If they don't show up under Network > Network, you need to install the *Samba* file-sharing service. Search *Software Manager* for *Samba,* then click Install. You're prompted to install additional software alongside it – these are known as dependencies, which *Samba* needs to run. Click Continue, enter your user password and wait for it to be installed.

If you're lucky, you'll immediately see the missing network devices appear, but if not, click the Network link above the file list to reveal an address bar. Replace **network:///** with **smb://** and enter the target server's IP address rather than its name (so **192.168.0.1** rather than **n100-server**) to access a list of shared folders. Click one to connect – if prompted for user credentials, choose Registered User to enter your username and password. Once connected, you'll see the folder appear under Network – to save time in future, right-click it and choose Add Bookmark to create a permanent link.

File permissions

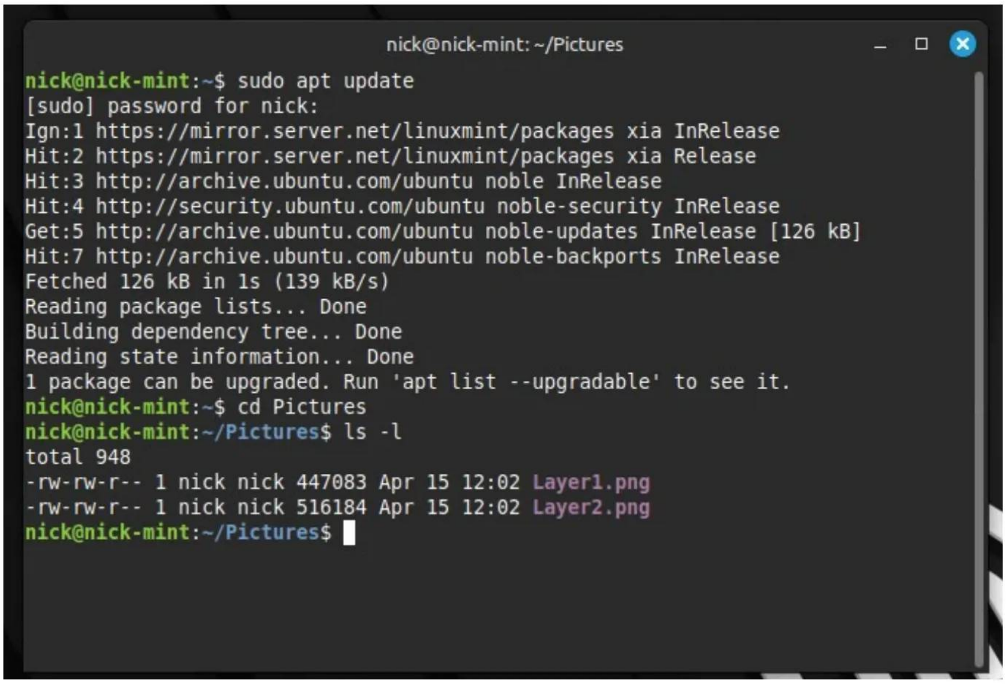
This seems a good point to talk about file permissions. These basically determine who has access to what files. Linux applies file permissions to three levels: user (the owner of the file, usually the account that the file was created under), group (enabling you to add users to multiple groups to give them access to certain files) and other (everyone else).

Each level is granted read, write and/or execute (for launching programs or accessing folders) permissions, expressed as **r**, **w** and **x** respectively when you list the contents of a directory using `ls -h` in the terminal. So, a file with permissions **rwxr-xr--** means the file's owner has full access (**rwx**), the listed group has read and execute (**r-x**) permissions, and all other users have read-only (**r--**) access.

In day-to-day use, you don't have to think about these much – you can review or change a file or folder's permissions via the Permissions tab when you right-click it and choose Properties. You'll notice most files in your user folder are owned by you, and assigned to a group with the same name as your user account. You have full access, while members of the specified group (and all other users) have read-only access to these files.

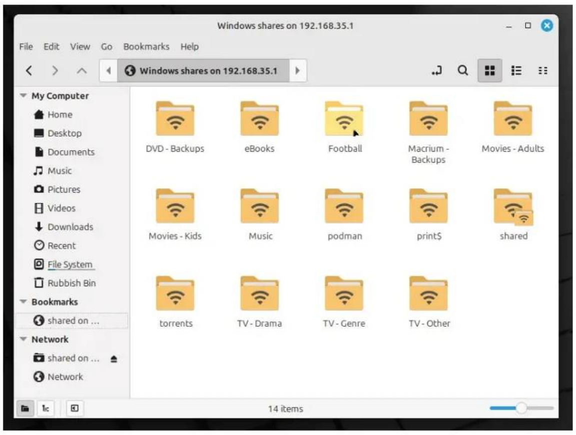
Command-line basics

Mint's Cinnamon desktop bends over backwards to enable you



```
nick@nick-mint:~$ sudo apt update
[sudo] password for nick:
Ign:1 https://mirror.server.net/linuxmint/packages xia InRelease
Hit:2 https://mirror.server.net/linuxmint/packages xia Release
Hit:3 http://archive.ubuntu.com/ubuntu noble InRelease
Hit:4 http://security.ubuntu.com/ubuntu noble-security InRelease
Get:5 http://archive.ubuntu.com/ubuntu noble-updates InRelease [126 kB]
Hit:7 http://archive.ubuntu.com/ubuntu noble-backports InRelease
Fetched 126 kB in 1s (139 kB/s)
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
1 package can be upgraded. Run 'apt list --upgradable' to see it.
nick@nick-mint:~$ cd Pictures
nick@nick-mint:~/Pictures$ ls -l
total 948
-rw-rw-r-- 1 nick nick 447083 Apr 15 12:02 Layer1.png
-rw-rw-r-- 1 nick nick 516184 Apr 15 12:02 Layer2.png
nick@nick-mint:~/Pictures$ 
```

Don't shy away from using the terminal – it'll soon become second nature to use. And you have Timeshift as a fail-safe.


Windows shares on 192.168.35.1
File Edit View Go Bookmarks Help
Windows shares on 192.168.35.1
My Computer
Home
Desktop
Documents
Music
Pictures
Videos
Downloads
Recent
File System
Rubbish Bin
Bookmarks
shared on ...
Network
shared on ...
Network
DVD - Backups
eBooks
Football
Macrium - Backups
Movies - Adults
Movies - Kids
Music
podman
print$
shared
torrents
TV - Drama
TV - Genre
TV - Other
14 items

You'll need to install an additional package – Samba – to gain access to many shared folders on your network.

to avoid having to interact directly with Linux's underlying shell. However, you shouldn't be afraid to take a closer look – press Ctrl+Alt+T to open the terminal, which enables you to interact with the shell without leaving the comfort of your desktop. Now type in the following commands, which check and update your system:

```
$ sudo apt update
$ sudo apt upgrade
```

The *sudo* command instructs Linux to give *sudo* administrator privileges, so you need to enter your user password the first time you enter it in a new terminal window. Virtually anything you do from the desktop can be done in the terminal, and over time you'll probably find it's often faster to press Ctrl+Alt+T to issue a few quick commands rather than digging around in *System Settings* or other apps.

We've covered the terminal many times in **LXF**, but going forward you'll find plenty of online help and tutorials. Start with Terminal Tutor (**www.terminaltutor.com**), which can teach you the basics using an online terminal emulator.

Apps from other sources

We've already touched on installing software through Mint's *Software Manager.* That covers packages hosted in official Linux Mint repositories as well as Flatpak. The main repositories are fine as they go, but their biggest drawback is that many applications held there aren't updated particularly often (sometimes only whenever you upgrade to a major new version of Linux Mint). This is because applications require other programs known as dependencies, and different versions of apps can require different versions of dependencies, which could lead to broken packages if not handled with care.

Flatpak eliminates this problem by bundling all the required dependencies for an application with the app, which is then run in its own isolated sandbox. This means the app has the correct versions of those dependencies without breaking other apps. The downside is that Flatpak-bundled apps are significantly larger than their system repository counterparts.

If you're looking for the latest version of an app and you can't find it in *Software Manager,* there are other places to look, too. Snap is Ubuntu's alternative to Flatpak but is blocked by default in Mint. Visit **https://snapcraft.io/docs/installing-snap-on-linux-mint** if you can't source an app or app version from elsewhere.

Other install options

Some apps require you to add their own repository to install them – you can add these by choosing Edit > Software Sources from *Update Manager,* then adding the repo to the PPAs or Additional Repositories tab. These repos can then be updated more frequently.

Other programs provide self-contained installer files in DEB format. Once downloaded, double-click the DEB and click Install Package to add it to the system. Others provide self-contained files that work in a similar way to Flatpak, albeit as a portable installation. These files are distributed with an AppImage extension. After downloading, you may need to right-click the file and choose Properties > Permissions, then tick Allow Executing File As Program to get it to work. If you find yourself frequently using AppImages, go to **https://github.com/TheAssassin/AppImageLauncher** to download version 2.2.0 of *AppImageLauncher* as a DEB file (choose the AMD64 version). Once installed, it integrates AppImages into your installation, including adding shortcuts to the Mint menu. **LXF**

QUICK TIP

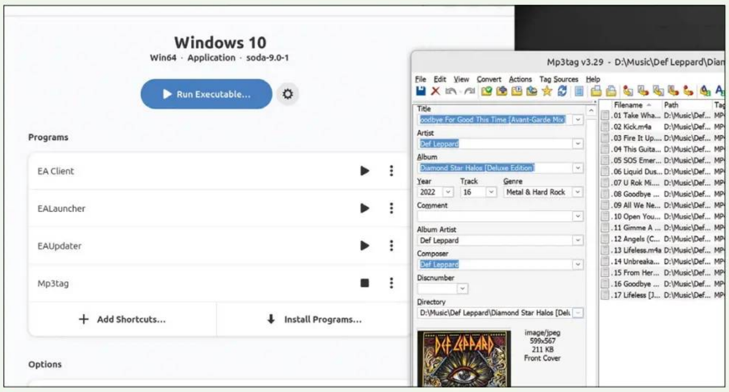
Be aware that Windows updates can often change Samba sharing settings, so if you lose network access to a Windows share it could be due to a recent update.

RUNNING OLD WINDOWS APPS

One key priority is to port over as many apps from your old PC as possible. Visit a program's website to see if a Linux version is available, then follow the instructions to install it. If no Linux build exists, you have two choices. The first is to source an alternative – start your search at **https://alternativeto.net** by locating the app in question, then click Linux as a filter to list potential replacements.

Another option is to investigate *Wine,* a compatibility layer that attempts to make it possible to run Windows applications natively in Linux, with mixed success. To see what apps (mostly games) are covered, visit **https://appdb.winehq.org** to search for specific apps to see if the program and version you have can be made to work.

Find out more about the project at **www.winehq.org** – *Wine* itself is tricky to use, so instead try *Bottles* (**https://usebottles.com**), which attempts to simplify the setting up of each application's own sandboxed environment, or bottle. You still need to do a fair bit of setting up and learning on the go (make sure you bookmark **https://docs.usebottles.com** and install *Flatseal* from *Software Manager* to allow you to expose your bottles to your user folders), but don't be put off if an application isn't listed at all – it just hasn't been tried yet. So, once you've familiarised yourself with how *Wine* works, feel free to conduct your own experiments.


Windows 10
Win64 · Application · soda-9.0-1
Run Executable...
Programs
EA Client
EALauncher
EAUpdater
Mp3tag
Add Shortcuts...
Install Programs...
Options
Mp3tag v3.29 - D:\Music\Def Leppard\Diam
File Edit View Convert Actions Tag Sources Help
Title
Artist
Def Leppard
Album
Diamond Star Halos (Deluxe Edition)
Year
2022
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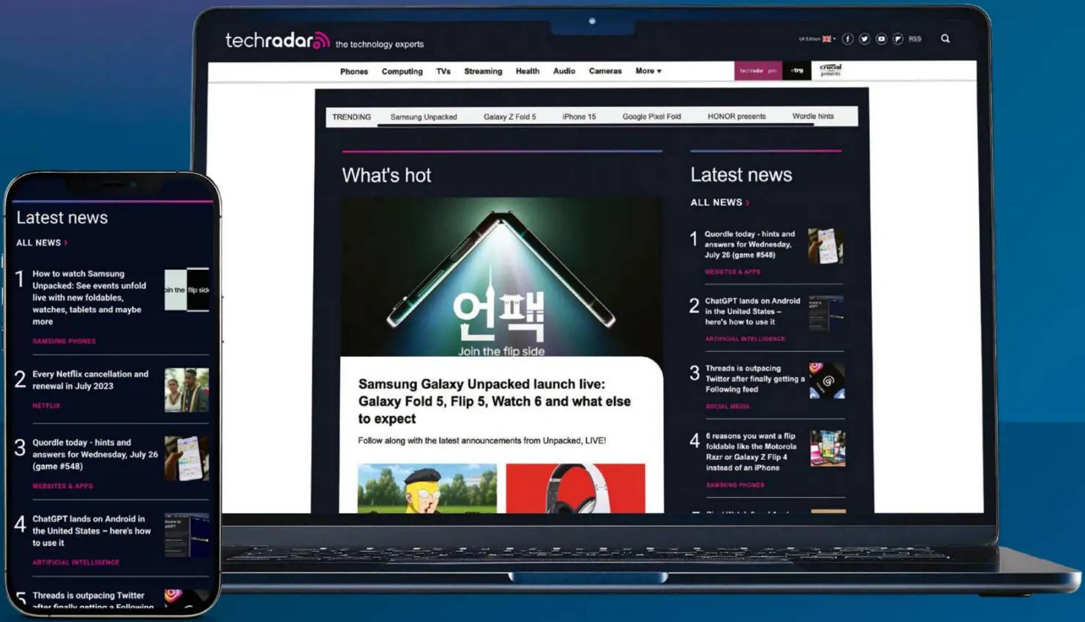
Front Cover

It needs configuring, but you may be able to resurrect old Windows programs with Bottles.

Meet the technology experts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4 6 reasons you want a flip foldable like the Motorola Razr or Galaxy Z Flip 4 instead of an iPhone
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the technology experts

3Jw8GGqdiRsHphQFjEgfZw==

Blast off with coding, making and AI!

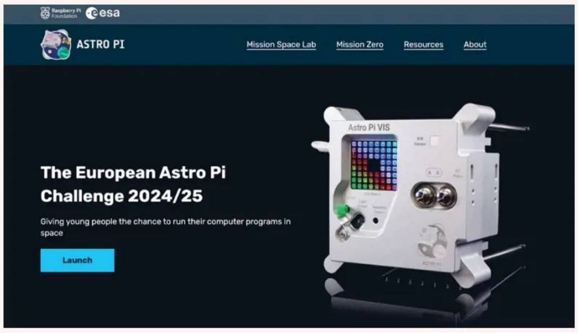
From space-based competitions to running AI at home, the Pi Foundation has you covered.

As the old *Pi User* section drifts off to the great magazine in the sky, we thought we'd leave you with projects, projects, projects! The number of class-leading, cutting-edge resources available today is astounding and for all levels. One of the most eye-catching was the European Space Agency-backed Astro Pi competitions, giving young people the chance to have their own code run in space.

By the time you read this, the 2024/25 projects will have been run and wrapped up with certificates making orbital burns to all the lucky participants. But now is the perfect time to start thinking and talking about, and planning your own Astro Pi project for 2026. The competition opens for submissions in September 2025.

As is now the way, there are two options: the more accessible Mission Zero suitable for beginners, solo entrants or teams up to four people, and Mission Space Lab for teams up to six that are being supervised by a mentor.

It's an exciting and inspirational way to get young people involved in coding. See: **https://astro-pi.org/#chooseyourmission**



The European Astro Pi Challenge 2024/25

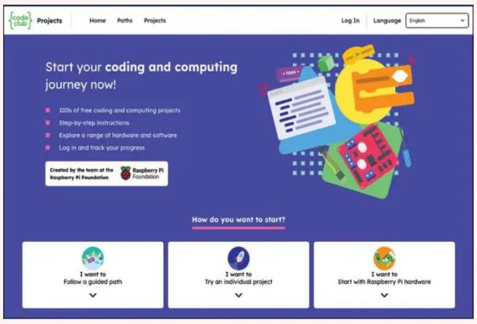
Giving young people the chance to run their computer programs in space

How else can you get to space?

Code Club

We're in it together.

For fun, for learning or for family time, Code Club offers a vast range of beautifully presented single projects and entire courses. Aimed to get everyone up and running with code and computing, they can take utter beginners and train them up in Scratch, Python, Unity, web design and more. Find out more: **https://projects.raspberrypi.org**



Start your **coding and computing** journey now!

- 100s of free coding and computing projects
- Step-by-step instructions
- Explore a range of hardware and software
- Log in and track your progress

Created by the team at the Raspberry Pi Foundation

How do you want to start?

I want to Follow a guided path

I want to Try an individual project

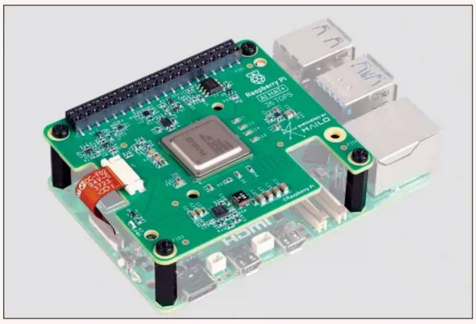
I want to Start with Raspberry Pi hardware

Go start your own Code Club!

AI smarts

Enter a world of LLMs.

Talk of AI has swept the world but it's a deeply complex technology that goes way beyond *ChatGPT* prompts. Despite its tiny size, the Pi is all set for AI and TOPS generation, and there's a suite of well-designed learning materials so everyone can become a master AI coder. Get started: **www.raspberrypi.org/teach/ai-education**



An AI HAT is the TOPS.

CREDIT: raspberrypi.org

Les Pounder works with groups such as the Raspberry Pi Foundation to help boost people's maker skills.

» THE END IS PI

All good things come to an end, and after 25 years (14 of which I was part of and, yes, I checked my old emails), *Linux Format* is bowing out gracefully.

The *Pi User* section started back in **LXF195**, and our first story was the exciting news of the Raspberry Pi 2. A quad-core ARM Linux computer that saw me travelling down to Cambridge in early January 2015 to test the latest Raspberry Pi and meet Eben Upton for an interview. This wasn't my first, nor last, interview with Eben Upton. The first was for *Full Circle Magazine,* an Ubuntu-centric community publication, and it saw me asking many Ubuntu-themed questions for the Raspberry Pi.

Over the years, I have covered every Pi release for *Linux Format,* and written features, reviews, tutorials, interviews and show reports for the magazine. Not bad for someone who started writing the user groups section for free back in 2011!

Linux Format was my first client when I went freelance, and over the years, it has given me the space and time to showcase what the Raspberry Pi can do. And how much I had to learn about writing. In fact, I am still learning and will forever be a student of this skill.

I leave this final *Pi User* section by giving thanks to Graham Morrison for taking a chance on me back in 2013. Mike Saunders for enabling me to write my user group and event adventures. And finally, huge thanks to Neil Mohr for his guidance and for pushing me in the right direction when I needed it.

Most importantly, thanks to you for reading *Linux Format,* and for reaching out to me.

Ubuntu 25.04 Beta

For his final Linux Format review, **Les Pounder** goes back to where it all started for him: Ubuntu and the Raspberry Pi.

IN BRIEF

Ubuntu 25.04 for the Raspberry Pi 5 looks and feels great. It's an excellent desktop OS, but this is not the OS for makers who want an out-of-the-box experience. It is better than 24.10, also an interim release that provides just nine months of support, but for now, Ubuntu 24.04 is still the king of Ubuntu for the Raspberry Pi.

Ubuntu 25.04, code-named Plucky Puffin, is the latest interim release of the popular Linux distro and we're taking a look at the most recent beta, ahead of its April launch. Powered by Linux Kernel 6.14, a kernel that improves hardware support, Ubuntu 25.04 for all 64-bit Raspberry Pis (3, 4, 400, 5 and 500) brings a stable distro for those who want to use their Raspberry Pi as a computer. Sure, makers can make using Ubuntu, but you'll need to adapt your workflow to accommodate a few quirks.

For our installation, we chose to use a Pi 5 16GB at stock CPU and GPU speeds, with an NVMe drive, as it offers a significant speed boost over microSD. You could also run from USB 3, a good compromise between microSD cost and NVMe speed. We chose the Pineboard HatDrive Nano for our PCIe interface, and a generic PCIe Gen 3 NVMe SSD. First boot sees Ubuntu configure itself, and ask questions such as username, password and hostname.

We are then presented with the ever-lovely Ubuntu desktop. It looks the same as 24.10 and 24.04, apart from the puffin background. The Gnome 48-based desktop looks very similar to the previous Gnome 47 in 24.10. The user interface is the classic Ubuntu: app launcher on the left, quick access to settings top-right.

Web browser video playback is where the Raspberry Pi has always dropped the ball, and Ubuntu 25.04 is no different, sadly. At 1080p 60, *Big Buck Bunny* dropped 80% of the frames when full-screen. Dropping down to 720p fared better, 'just' 47% dropped frames. Remember this was on a Raspberry Pi 5 16GB with an NVMe SSD, short of overclocking the Pi, this was the best outcome possible.

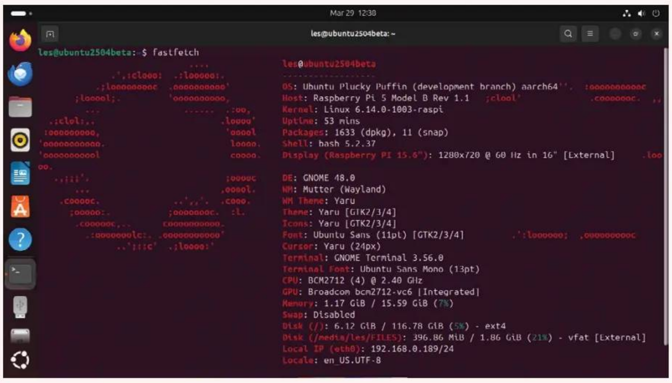
There is no direct support for the Raspberry Pi range of cameras with Ubuntu 25.04, much like its predecessors. If you want quick and easy access to a camera, use a USB webcam. The harder path sees you compiling libcamera for yourself. While it may not be too difficult for many, it is a friction point that could be overcome if the developers had the resources to do so.

The GPIO is accessible but you'll need LGPIOD or GPIO Zero if you want to make any electronic projects. It isn't too difficult to get a project going, but there is friction. Many Raspberry Pi GPIO projects are written with RPi.GPIO and GPIO Zero in mind, so you need to adapt them to work with Ubuntu.

Keeping the Pi 5 cool was the official Raspberry Pi Active Cooler, and Ubuntu 25.04 could communicate with the fan and trigger when the CPU got too hot. In older versions of Ubuntu, the CPU fan would constantly spin at 100%; thankfully, this has been fixed.

Is Ubuntu 25.04 better than 24.04? Short answer, no. If you really want to be on the bleeding edge, go for it! But Ubuntu 24.04.2 provides a much better experience in the long run. That said, even the beta we tested was stable and there were no crashes during our testing.

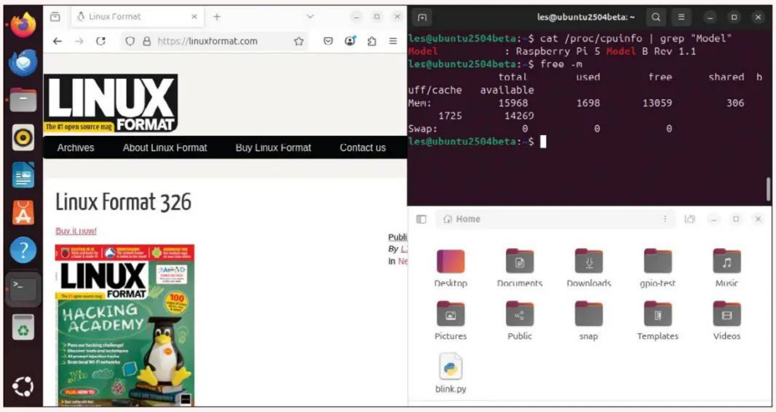
We've written about Ubuntu 25.04's flaws, so let's end on a high note. The user interface feels slick and professional. It looks the part and with the power of the Raspberry Pi 5, it feels it. With a Pi 5 8GB and NVMe SSD, we'd happily use this as a daily driver for general work tasks. For maker projects, Raspberry Pi OS is still the gold standard, but Ubuntu is creeping up on it. LXF



```
les@ubuntu2504beta:~$ fastfetch
les@ubuntu2504beta
------------------
OS: Ubuntu Plucky Puffin (development branch) aarch64
Host: Raspberry Pi 5 Model B Rev 1.1
Kernel: Linux 6.14.0-1003-raspi
Uptime: 53 mins
Packages: 1633 (dpkg), 11 (snap)
Shell: bash 5.2.37
Display (Raspberry PI 15.6"): 1280x720 @ 60 Hz in 16" [External]

DE: GNOME 48.0
WM: Mutter (Wayland)
WM Theme: Yaru
Theme: Yaru [GTK2/3/4]
Icons: Yaru [GTK2/3/4]
Font: Ubuntu Sans (11pt) [GTK2/3/4]
Cursor: Yaru (24px)
Terminal: GNOME Terminal 3.56.0
Terminal Font: Ubuntu Sans Mono (13pt)
CPU: BCM2712 (4) @ 2.40 GHz
GPU: Broadcom bcm2712-vc6 [Integrated]
Memory: 1.17 GiB / 15.59 GiB (7%)
Swap: Disabled
Disk (/): 6.12 GiB / 116.78 GiB (5%) - ext4
Disk (/media/les/FILES): 396.86 MiB / 1.86 GiB (21%) - vfat [External]
Local IP (eth0): 192.168.0.189/24
Locale: en_US.UTF-8
```

Ubuntu 25.04 may be in beta, but its performance is solid and it looks incredible.



```
les@ubuntu2504beta:~$ cat /proc/cpuinfo | grep "Model"
Model           : Raspberry Pi 5 Model B Rev 1.1
les@ubuntu2504beta:~$ free -m
               total        used        free      shared  b
uff/cache   available
Mem:           15968        1698       13059         306
    1725       14269
Swap:              0           0           0
les@ubuntu2504beta:~$ 
```

Quarter-window tiling may be old hat, but it performs exceptionally well, even on the low-power Raspberry Pi 5.

VERDICT

DEVELOPER: Canonical
WEB: https://ubuntu.com
LICENCE: Mixed

FEATURES	7/10	EASE OF USE	8/10
PERFORMANCE	8/10	DOCUMENTATION	9/10

Looks and performs great. A professional-looking Linux for the Pi, but makers still need to look elsewhere for their fix.

» **Rating 8/10**

QiDi Plus4

Picking up where the Bambu left off, **Denise Bertacchi** finds a practical if unexciting machine.

SPECS

Vol: 305 x 305 x 280mm
Type: PLA/PETG/TPU/ABS (up to 370°C)
Extruder: Direct drive
Nozzle: 0.4mm (dual-metal high flow)
Plate: Double-sided PEI flex plate, heated
Levelling: Automatic
Extras: Runout sensor, 1080p camera, active heater, additional multi-colour box
Comms: LAN, Wi-Fi, USB flash drive
Control: 5-inch 800x480 colour touchscreen
Size: 505 x 487 x 550mm, 27kg

If you're into practical printing and crave more build volume than the Bambu Lab X1 Carbon can provide, the QiDi Plus4 might be just what the doctor ordered. With its 305 x 305 x 280mm build area and toasty heated chamber, the Plus4 can knock out incredible prints in technical filaments like ABS, ASA or nylon, while also doing a nice job with PLA and TPU – if you don't mind popping the lid off.

tom's HARDWARE

It's a big and mean, 3D printing machine.

The Plus4 delivers all the perks you would expect from a high-class printer: hands-free calibration and automatic levelling, lightning speed with input shaping, a high-flow hotend, a built-in camera, and lots of fans for cooling and air filtration. The heated chamber is a newer feature we love to see, and it really helps when printing with a squirrelly filament prone to warping.

QiDi is also teasing the release of a four-colour QiDi Box, which is promised in the coming months. The Plus4 is ready to go with the internal filament cutter and wiper it would need for swapping colours, which suggests this machine can be easily upgraded.

The only problem with the Plus4 is filament loading. We found you really have to jam the filament in to get it through to the extruder. Since it purges straight into a black chute at the back, it can be difficult to tell if the new material is feeding unless you stand squinting at it.

The Plus4 is tailor-made for engineering filaments. It has a heated chamber that can hit 55°C, a build plate that goes to 100°C, and a nozzle that can reach 370°C – far hotter than most consumer printers. This enables the printer to handle more industrial-grade materials, such as Polymaker's Fiberon PPS-CF.

QiDi is using a fork of regular *Klipper* that has been customised for its machines. Unlike some companies, the firmware is still open and accessible for tweaking.

The lid is easily removed to provide air flow for PLA, PETG and TPU. But when you want to run ABS, ASA or anything else that needs a toasty warm enclosure, a separate heater is located inside the chamber for an extra boost.

QiDi includes a copy of *QiDiStudio,* a custom program based on Bambu Lab's slicer, which is based on *PrusaSlicer,* which is based on the open source *Slic3r.* The program will look very familiar to anyone coming from those fan bases.

Running Benchy using Speed Benchy rules and turning everything off that could slow down the printer, we cranked the acceleration up to the max and let her rip using the default speed of 300mm/s. The result was something of a squishy mess, but it printed in a blazingly fast 12 minutes and 58 seconds, which puts it in the top five of our fastest 3D printers. For comparison, an Ender 3 S1 running at its top speed of 100mm/s would take 55 minutes to print a standard Benchy.

Obviously, the Speed Benchy is no mark of this printer's quality, only its ability to smash out a Benchy-shaped object. When the printer was run at ordinary speeds (around 200-300mm/s), it produced spectacularly fine prints. LXF

Log is famous for rolling over your neighbour's dog, but also check out that fine detail!

VERDICT

DEVELOPER: QiDi
WEB: http://uk.qidi3d.com
PRICE: £669

FEATURES	8/10	EASE OF USE	7/10
PERFORMANCE	9/10	VALUE	7/10

The quality is excellent, but its current lack of colour options makes this machine more ideal for business-minded practical printing rather than home hobbyists.

» Rating 8/10

Orange Pi RV2

Never one to miss sticking it to the Pi Man, **Tam Hanna** tests the best little RISC-V board he's seen.

SPECS

CPU: Ky X1 8-core RISC-V
AI: 2TOPS
Mem: LPDDR4X 2-8GB
SSD: SPI 128MB; optional 256MB, eMMC 16-128GB
PCIe: 2x M.2 PCIe 2.0 x2
Comms: Wi-Fi 5, BT 5, BLE, 2x Gigbit Ethernet
Video: HDMI 2.0, 1,920x1,440 @ 60fps, 1x 4-lane MIPI DSI
Camera: 2x 4-lane MIPI CSI
Ports: 3x USB 3.0, 1x USB 2.0 + header, 3.5mm audio
GPIO: 26-pin, UART, I2C, SPI, PWM
Extra: Boot, reset, power, RTC header, debug header
Size: 89x56x1.6mm

Being based on an open, patent-unencumbered instruction set architecture (ISA), RISC-V processors appear to be a natural companion to Linux. So far, however, evaluating RISC-V Linux has been held back by the lack of affordable hardware that is also comfortable to use.

With a starting price of around £45 for the 2GB version or £65 for the 8GB version, plus shipping, from the likes of AliExpress (**www.aliexpress.com**), the Orange Pi RV2 is an affordable way to get started with Linux on open source hardware.

Its feature set rivals that found on other single-board computers. For instance, three USB 3.0 ports and one normal USB 2.0 port ensure easy peripheral connection, while a full-size HDMI port enables digital video output. As for professional interfaces, two M.2 slots and an eMMC socket allow for the connection of robust, high-bandwidth peripherals, such as flash memory or a WAN card.

Power can be supplied via a USB-C power supply. AliExpress seller Shenzhen Xunlong recommends the use of its own one based on silicon carbide technology, which provides a 27W output power. When running *StressNG*, the system does not become excessively hot – the reel at **www.instagram.com/reel/DILqTAatctD/** shows the thermal situation.

Official Ubuntu support

Even though the Ubuntu images for the Orange Pi RV2 must be downloaded from Shenzhen Xunlong's Google Drive, the files do come with an official endorsement from Ubuntu, as per a blog post found at **https://canonical.com/blog/ubuntu-developer-images-now-available-for-orangepi-rv2-a-low-cost-risc-v-sbc**. Thanks to the official support, package updates (think **apt-get**) can be obtained directly from the Ubuntu repositories, leading to a seamless upgrading experience.

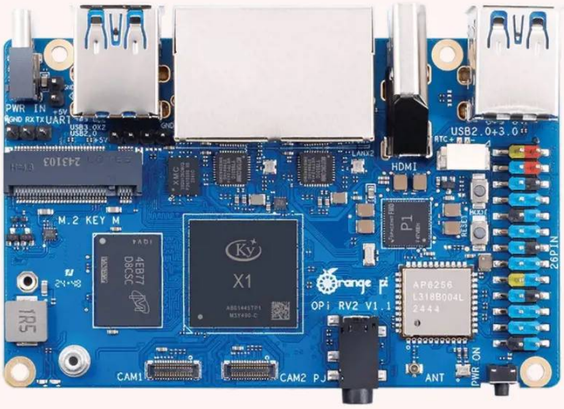
This, however, does not mean that all packages known from X86/X64 Ubuntu are also available on the new machine. Packages such as *Sysbench* are not available due to issues with the underlying libraries not being supported on RISC/V yet:

```
make[3]:... lj_arch.h:59:2: error: #error "No support for this architecture (yet)"
```

In such a situation, a RISC-V single-board computer cannot be used unless you are willing to port the package manually. This, however, does not affect most normal use cases – most if not all packages needed for typical desktop use are available.

Rich GPIO

The Orange Pi RV2 comes with a 26-pin GPIO header for control tasks. Hardware support is excellent right out of the box, with the official Ubuntu image supporting the Raspberry Pi-inspired wiringOPI library known and liked from other Orange Pi models.



It doesn't match the Raspberry Pi 4, but it's more than fast enough.

Running a simple GPIO stress test based on digitalWrite then yields a wave with a speed of approximately 1.13MHz, which is more than enough for most measurement and control tasks. One neat touch of the board design is the coloured background on the GPIO connector – it simplifies finding the right pin when connecting external hardware.

Take that Pi 4!

Even though *Sysbench* is unavailable for this SBC, benchmarking systems such as *Phoronix* can run on the Orange Pi RV2. Thanks to their ability to eliminate failed modules, a geometric mean result can be computed in the end.

In practice, the 8GB model achieves about half the compute performance of a Raspberry Pi 4 with similar amounts of RAM. While this is not cutting-edge by any stretch of the imagination, it is more than fast enough for evaluation and control tasks. Furthermore, the Orange Pi RV2 offers effectively double the performance of the HiFive Unmatched, a much more expensive yet slower board. LXF

VERDICT

DEVELOPER: Orange Pi
WEB: www.orangepi.org
PRICE: £45 2GB (£65 8GB)

FEATURES	9/10	EASE OF USE	7/10
PERFORMANCE	7/10	VALUE	8/10

Affordable, yet fully-featured way to experiment with Linux on the open source RISC-V ISA; there's basic AI but no GPU.

» Rating 8/10

EXO

Credit: https://github.com/exo-explore/exo

Network AI clusters to model and move on

Few things can rival the computing demand of AI models. **Tam Hanna** helps you spread the load with a cluster of affordable systems.

OUR EXPERT

Tam Hanna hates all things Raspberry Pi and will mention the Orange Pi at every chance! Follow him at **www.instagram.com/tam.hanna/**

Mainframes and similar large systems command a premium price. Since time immemorial, PC enthusiasts have been looking for a way to combine a large number of inexpensive computers. The arrival of high-performance SoCs such as the RK3588 made single-board computers a viable alternative for cluster applications.

Exo is a cluster system with a wide array of promises. The developers pledge to support both Mac OS and Linux, and promise good performance even when running on extremely slow individual systems. What's more, the system promises a comfortable web interface, thereby ensuring that model management does not become a chore.

We are taking the developer team at its word. To find out more, we are putting together a cluster consisting of various machines, from process computers to a machine with an Nvidia GPU.

Start the control terminal

We are starting with the most powerful machine we'll be using: our trusty MSI mobile workstation, whose RTX2060 GPU with 6GB of VRAM might just be enough to host a decent fragment of a model. Ubuntu 22.04 LTS shall be used as the operating system. The documentation at **https://github.com/exo-explore/exo** reveals that the developer team recommends compilation from source.

For GPU acceleration, the correct configuration of CUDA is required. Because this has been discussed multiple times in previous issues, we shall assume acceleration works.

Next, check the Python version – the developers recommend it to be 3.12 to avoid a problem with asyncio. In the following steps, the following version will be used:

```
$ python --version
Python 3.12.9
```

Updating Python

The default version of Python installed on Ubuntu 22.04 is 3.10. As changing the main Python interpreter of an Ubuntu installation is considered a bad idea, instead, perform the following three steps to add an additional PPA and download Python 3.12:

```
$ sudo add-apt-repository ppa:deadsnakes/ppa -y
$ sudo apt update
$ sudo apt install python3.12-full
```

Next, add the newly downloaded interpreter to the update-alternatives system. This is not done automatically while the package is installed but requires the following command:

```
$ sudo update-alternatives --install /usr/bin/python
python /usr/bin/python3.12 7
```

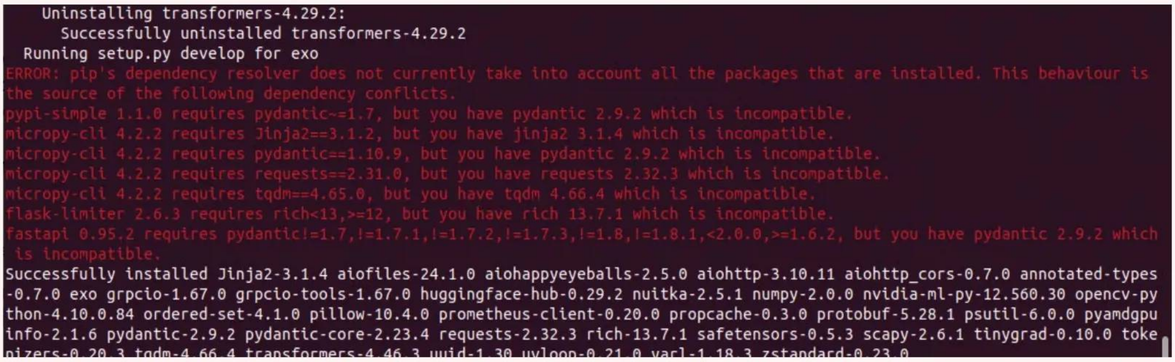
When done, the Python command yields the above-mentioned result. After ensuring you have a compatible version of Python, download runtime and dependencies as follows:

```
$ git clone https://github.com/exo-explore/exo.git
$ cd exo
$ pip install -e .
```

Pip might emit a partial error similar to the one

QUICK TIP

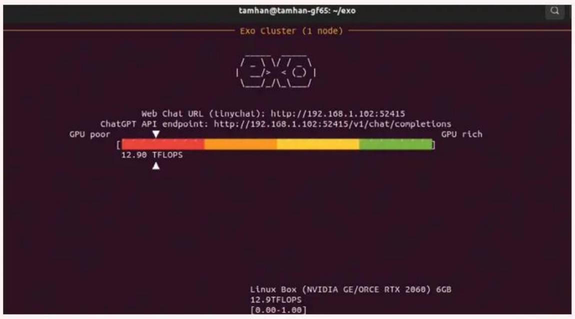
When originally submitted, *Exo* ran on the Raspberry Pi and Orange Pi. Post-submission a regression seems to have broken this. Typically we'd boot this along an issue or two until it was fixed, but here we are not wanting to waste a good project...



```
    Uninstalling transformers-4.29.2:
      Successfully uninstalled transformers-4.29.2
  Running setup.py develop for exo
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is
the source of the following dependency conflicts.
pypi-simple 1.1.0 requires pydantic~=1.7, but you have pydantic 2.9.2 which is incompatible.
micropy-cli 4.2.2 requires Jinja2==3.1.2, but you have jinja2 3.1.4 which is incompatible.
micropy-cli 4.2.2 requires pydantic==1.10.9, but you have pydantic 2.9.2 which is incompatible.
micropy-cli 4.2.2 requires requests==2.31.0, but you have requests 2.32.3 which is incompatible.
micropy-cli 4.2.2 requires tqdm==4.65.0, but you have tqdm 4.66.4 which is incompatible.
flask-limiter 2.6.3 requires rich<13,>=12, but you have rich 13.7.1 which is incompatible.
fastapi 0.95.2 requires pydantic!=1.7,!=1.7.1,!=1.7.2,!=1.7.3,!=1.8,!=1.8.1,<2.0.0,>=1.6.2, but you have pydantic 2.9.2 which
 is incompatible.
Successfully installed Jinja2-3.1.4 aiofiles-24.1.0 aiohappyeyeballs-2.5.0 aiohttp-3.10.11 aiohttp_cors-0.7.0 annotated-types
-0.7.0 exo grpcio-1.67.0 grpcio-tools-1.67.0 huggingface-hub-0.29.2 nuitka-2.5.1 numpy-2.0.0 nvidia-ml-py-12.560.30 opencv-py
thon-4.10.0.84 ordered-set-4.1.0 pillow-10.4.0 prometheus-client-0.20.0 propcache-0.3.0 protobuf-5.28.1 psutil-6.0.0 pyamdgpu
info-2.1.6 pydantic-2.9.2 pydantic-core-2.23.4 requests-2.32.3 rich-13.7.1 safetensors-0.5.3 scapy-2.6.1 tinygrad-0.10.0 toke
nizers-0.20.3 tqdm-4.66.4 transformers-4.46.3 uuid-1.30 uvloop-0.21.0 yarl-1.18.3 zstandard-0.23.0
```

This warning is all sizzle and no steak.

»

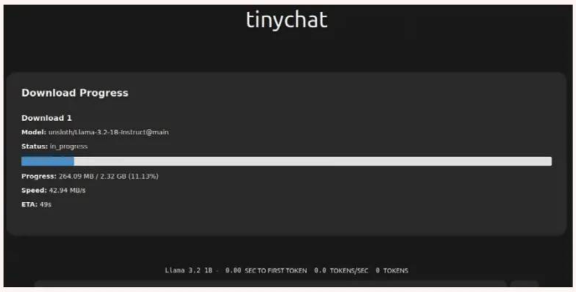


```
tamhan@tamhan-gf65: ~/exo
Exo Cluster (1 node)

       Web Chat URL (tinychat): http://192.168.1.102:52415
  ChatGPT API endpoint: http://192.168.1.102:52415/v1/chat/completions
GPU poor                                                           GPU rich
 [                                                                ]
 12.90 TFLOPS

                           Linux Box (NVIDIA GE/ORCE RTX 2060) 6GB
                           12.9TFLOPS
                           [0.00-1.00]
```

Initially, only one workstation is present.



tinychat

Download Progress

Download 1

Model: unsloth/Llama-3.2-1B-Instruct@main

Status: in_progress

Progress: 264.09 MB / 2.32 GB (11.13%)

Speed: 42.94 MB/s

ETA: 49s

```
Llama 3.2 1B - 0.00 SEC TO FIRST TOKEN  0.0 TOKENS/SEC  0 TOKENS
```

Evo starts to download any relevant components.

QUICK TIP

Jeff Atwood's classic blog, found at https://bit.ly/lxf329jeff, describes the OG way of combining cheap computers to achieve more performance. It is interesting not only from a historical perspective.

shown in the screenshot *(see previous page)*. This is noncritical.

Next, enter `source install.sh` to start the compilation. When done, no errors should show up - instead, a success message similar to `Successfully built exo nuitka uuid tinygrad` should be found in the program's output. Warnings about an outdated version of *Pip* can be ignored.

The install command leaves the terminal inside the virtual environment – this can be distinguished by the prompt having a prefix like **(.venv)**. Enter *Exo* to start the cluster management window, which initially presents itself similarly to the screenshot *(above)*.

The status screen displays two URLs. One exposes an API compatible with applications that use the *ChatGPT* server. Entering the other URL starts the web chat. The area on the left-hand side of the screen always displays a few models. These are often yet to be downloaded, a fact revealed when the Downloaded-Only checkbox is ticked.

The drop-down selector provides a variety of models. The interface tries to limit the choices displayed to what is compatible with the available hardware. In the case of our current configuration with only 6GB of VRAM, many models either don't show up or are displayed with a rotating Check Download Status sign.

We proceeded to select Llama 3.2 1B and then clicked the Download button. This led to the progress bar being displayed in the middle of the control interface.

Keeping an eye on the download process is best done via the task manager – when CPU and network consumption stop, the model download has been completed. However, some more time will pass before the web interface registers the model as downloaded.

Next, click the model and enter a friendly `hello`. After pushing the return key, *Exo* gets to work and shows an answer along with a status line similar to

```
Llama 3.2 1B - 14.60 SEC TO FIRST TOKEN 1.8 TOKENS/
SEC 9 TOKENS
```

Excursus: CPU only?

Exo's generation rate is not particularly fast. This is caused by a known bug where the Python runtime uses only one CPU core, creating a bottleneck. Working around this can be done by invoking the program as per the following:

```
$ CLANG=1 exo
```

Enabling this special regimen on the Linux workstation with the GPU has turned out to be inefficient – apparently, the CLANG mode disables GPU acceleration.

Bringing up a Pi

After having experimented with *Exo* as a standalone model host, the next victim is a Raspberry Pi 5 with 8GB of RAM. Select a 64-bit version of the operating system – in the following steps, the file **2024-11-19-raspios.img** is used.

After startup, configure the SSH interface so as to simplify access. After that, check the installed Python version – when using the image mentioned above, the version will look as follows:

```
$ python --version
Python 3.11.2
```

The Raspberry Pi Foundation is relatively slow when it comes to updating the Python version used on its process computer. The first act of remedy involves downloading and unpacking the Python source code via the following commands:

```
$ mkdir pythonspace
$ cd pythonspace/
$ wget https://www.python.org/ftp/python/3.12.4/
Python-3.12.4.tgz
$ tar zxvf Python-3.12.4.tgz
$ cd Python-3.12.4/
$ ./configure --enable-optimizations
$ sudo make altinstall -j 4
```

At this point, a high-quality power supply is required, and a fan is recommended. Due to the complexity of the Python environment, expect up to 15 minutes or around two cups' worth of tea of compile time.

One interesting aspect of the process involves that it also runs a set of tests during the compilation. These generate profiling information for a second, more optimised, compilation run.

When done, the system announces the installation of *Pip* via `Successfully installed pip-24.0`. Warnings about access rights can be ignored.

Successfully compiling Python depends on a variety of optional modules. Make sure you execute the following command:

```
$ sudo apt install build-essential zlib1g-dev
libncurses5-dev libgdbm-dev libnss3-dev libssl-dev
libreadline-dev libffi-dev  libsqlite3-dev libbz2-dev
```

If the SSL library or other components are missing, the combined Python version will be incomplete, which will lead to problems down the road. Deploying the actual program starts out by running the first three commands as follows:

```
$ git clone https://github.com/exo-explore/exo.git
$ cd exo
$ pip install -e .
```

The manually compiled *Pip* throws an error similar to `error: externally-managed-environment`. Ignore it without consequence – simply continue to enter the following command to ensure deployment:

```
$ source install.sh
```

One common source of trouble at this point involves a missing bz2 library. If the *Pip* download process fails with errors referring to the missing SSH library, a recompile of Python with the correct module is required.

In many cases, a wrong dependency – ARM SBCs are not of high importance in *Exo* land – similar to `ERROR: Could not build wheels for pyamdgpuinfo, which is required to install pyproject.toml-based projects` shows up. This is caused by a dependency to the AMD GPU information module, which can not be run on an ARM SBC.

This problem is best solved by running the following command, which then emits a list of all references in the source code:

```
~/exo/exo.egg-info $ grep -rnw '/home/hisu/exo' -e
'pyamdgpuinfo'
```

Then, remove them one by one from setup-relevant files. Runtime code files are not of significance, because they do not block installation – while the program runs, it seems to be able to figure out that it's not hosted on ARM on its own.

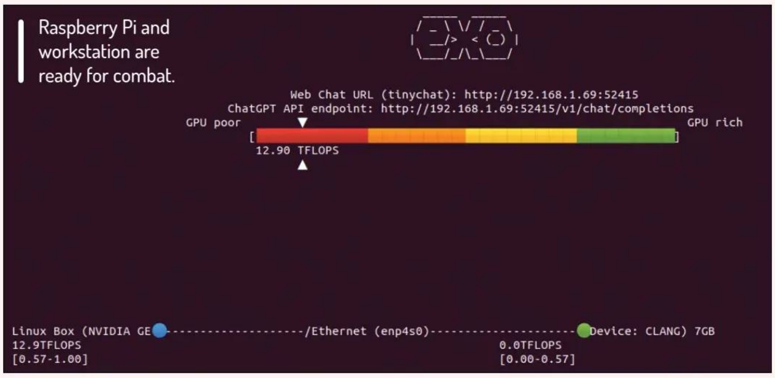
When done, run the installation command once again. It then succeeds, informing you about the successful execution of the *Exo* build process.

Given that the Raspberry Pi is a purely CPU-based system, invocation of the *Exo* web interface must be done via the following command:

```
~/exo $ CLANG=1 exo
```

If the workstation's instance runs, the resulting display looks like the one shown *(above-right)*. Be aware that UDP discovery takes some time.

Next, we return to the web interface – in some cases, a refresh is needed to make the second machine show up in the topology displayed at the top-right corner of the screen. Then, send another `hello` request.



Raspberry Pi and workstation are ready for combat.

```
 _____  _____
/ _ \ \/ / _ \
| __/>  < (_) |
\___/_/\_\___/

Web Chat URL (tinychat): http://192.168.1.69:52415
ChatGPT API endpoint: http://192.168.1.69:52415/v1/chat/completions
GPU poor                                                     GPU rich
[                                                                    ]
12.90 TFLOPS

Linux Box (NVIDIA GE------------------/Ethernet (enp4s0)--------------------Device: CLANG) 7GB
12.9TFLOPS                                                      0.0TFLOPS
[0.57-1.00]                                                     [0.00-0.57]
```

Given that the newly deployed *Exo* environment does not have the model files, the system reacts by displaying the above-mentioned download screen once again – each node of the cluster must have enough remanent storage to keep a full copy of all the model information. When done, send the greeting again – *Exo* rejects it, rather rudely, with an error similar to the following:

```
details = "Unexpected <class 'FileNotFoundError'>:
[Errno 2] No such file or directory: 'clang'"".
```

Fix this by installing the *clang* environment:

```
$ sudo apt-get install clang
```

Sadly, this is the end of the experiment. Attempting to run a query on a cluster containing an SBC from the Linux terminal ends with an error along the lines of

```
„Failed to fetch completions: Error processing prompt
(see logs with DEBUG>=2): <AioRpcError of RPC that
terminated with:
status = StatusCode.UNKNOWN".
```

We've reported the regression, so hopefully it'll be fixed by the time you read this. Even though *Exo* currently has issues running on Linux-based SBCs, the signs of the future are clear. Thanks to the simple setup process, running a cluster is not difficult. For experimentation, we also added an ageing IBM ThinkPad, which was accepted immediately.

If the *Exo* developer team fixes the issues (which were already reported), their product will become a powerful AI tool that deserves a place on every nerd's home network! **LXF**

QUICK TIP

If the installation displays 'Checking download status' for more than 15 minutes, you have probably encountered the bug described at https://bit.ly/lxf329bug.

» ADDING ROCKCHIP COMPUTE

The Orange Pi 5 Plus is a potentially more able SBC; *Exo* does offer currently broken support. If you have the hardware and want to try, visit Shenzhen Xunlong's website to download Ubuntu. We've used 1.2.0 XFCE. Follow the usual extraction intrusion to microSD.

Updating the Python version of the image is done as described above. However, the following steps must be done in sequence:

```
$ cd ~/pythonspace/Python-3.12.4
$ sudo make altinstall -j 4
$ sudo make install -j 4
```

After that, the installation can be accomplished via the source install command. When starting *Exo* by entering the command `CLANG=1 DEBUG=3 exo`, the system outputs a message similar to:

```
None of PyTorch, TensorFlow >=
2.0, or Flax have been found
```

This can be remedied by manually downloading the missing module as per the following command:

```
$ pip3 install torch torchvision
torchaudio --index-url https://
download.pytorch.org/whl/cpu
```

At this point, the program can, in theory, be run. Passing in the **CLANG** flag is mandatory here, because the Orange Pi is considered an Nvidia system for some reason. Loading the Nvidia graphics accelerator library leads to a core dump.

Sadly, attempting to actually execute a query in the cluster fails with an error similar to:

```
Failed to fetch completions:
Error processing prompt (see logs
with DEBUG>=2)
```

This is caused by an error local to the Orange Pi. This can be verified by starting *Exo* in standalone mode by entering the following command:

```
$ CLANG=1 exo run llama-3.2-1b
--prompt "What is the meaning
of exo?"
```

RASPBERRY PI

The art gallery at the end of LXF

Les Pounder wipes a tear from his eye as he writes his final Linux Format Raspberry Pi tutorial and chops onions…

OUR EXPERT

Les Pounder is associate editor at Tom's Hardware and a freelance maker for hire. He blogs about his adventures and projects at **http://bigl.es.**

YOU NEED

- **Any model of Pi**
- **Raspberry Pi OS on a microSD card**
- **An Adafruit 5-inch 800x480 display or similar**
- **Code: https://bit.ly/lxf329code**

This is Les's final Raspberry Pi tutorial after over a decade of writing them for *Linux Format!* It is a sad time, but as we bid a fond farewell to you all, we look back at the issues of work that every member of the team has put in, and to celebrate, we thought it would be nice to look back at all the *Linux Format* covers. But because these pages are all about the Raspberry Pi, let's make a cool project one last time! This project sees any model of Pi, connected to a small Adafruit display, randomly display a cover from the *Linux Format* archives.

A small screen like the Adafruit 5-inch screen we used is ideal because the image files are only 318x450 resolution, so an 800x480 screen (or smaller) gives better image quality than a 1080p display.

We'll be using PyGame to handle displaying the images. It makes short work of loading media files, making it ideal for beginners.

So, for the final time, let's build a project!

Setting up

First we need the images from the *Linux Format* website. Luckily, we saved you some time and included them in the download for this project. Think of it as a parting gift.

On the Raspberry Pi, open *Thonny* and create a new file. At the top of the new file, we need to tell the code where to find the Python interpreter (we'll be making this script executable later). Then we import four modules of prewritten code to use PyGame, work with the underlying OS for files and directories, randomly pick files, and pause the cover images:

```
#!/usr/bin/env python3
import pygame
import os
import random
import time
```

Now we create two functions. The first, **get_random_image**, locates a random image file from a directory that we pass as an argument when calling the function:

```
def get_random_image(image_folder):
```

The object **images** stores the list of images, specifically those that end with png, jpg, jpeg, bmp or gif, because they are image files:

LINUX FORMAT
MASTER THE AMAZING RASPBERRY PI

The final project – no, seriously! Lots of Linux Format issues, directly to your eyeballs.

```
   images = [f for f in os.listdir(image_folder) if f.lower().
 endswith((‘png’, ‘jpg’, ‘jpeg’, ‘bmp’, ‘gif’))]
```

If there are no images, then an error handler returns that none have been found:

```
   if not images:
       raise FileNotFoundError(“No images found in the
 folder.”)
```

Finally in this function, we return the full path to the randomly chosen image file:

```
   return os.path.join(image_folder, random.
 choice(images))
```

The second function displays the image. It has two arguments: the screen dimensions and the path to the image.

```
 def display_image(screen, image_path):
```

The object **image** is used to load the image file. We rotate the image 90 degrees so it is in portrait mode, then scale the image so it takes up the entire screen:

```
    image = pygame.image.load(image_path)
    image = pygame.transform.rotate(image, -90)
    image = pygame.transform.scale(image, (screen.get_
 width(), screen.get_height()))
```

Next we blit the image to the screen at position 0,0 (top-left). Blitting loads the image file into memory. Lastly for the function we update the PyGame display to show the image:

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The cover will change every five minutes, but you can easily change this in the code.

```
    screen.blit(image, (0, 0))
    pygame.display.update()
```

Inside a **while True** (forever) loop, we run the main code. First we set the image folder location:

```
while True:
    image_folder = "/home/pi/LXFPics/covers"
```

Then we initialise PyGame, and create an object, **screen**, to represent our display. The Adafruit 5-inch display we used has a resolution of 800x480, ideal for the cover images. We tell PyGame to use full-screen mode. The caption won't be seen, but we set it anyway:

```
    pygame.init()
    screen = pygame.display.set_mode((800, 480),
pygame.FULLSCREEN)
    pygame.display.set_caption("Random Image
Viewer")
```

Create an object, **running**, and store the value **True** inside it. We'll use this in an error trap. Using a **while** loop, we try to open a random image and store the details in **image_path**. Then we call the **display_image** function, passing the screen and **image_path** details:

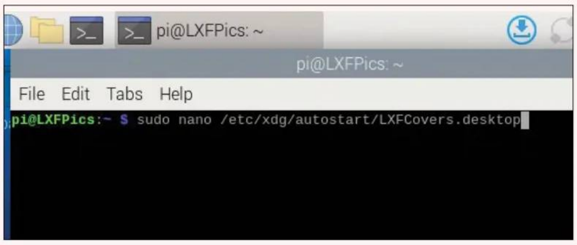
```
    running = True
    while running:
        try:
            image_path = get_random_image(image_folder)
            display_image(screen, image_path)
```

If an exception (error) occurs, specifically if a file is not found, the error is printed to the Python shell, then **running** is updated to **False**, triggering the app to exit:

```
        except FileNotFoundError as e:
            print(e)
            running = False
```

We tell the code to pause for 300 seconds between each change. Set this to one second when testing!

```
        for _ in range(300):
```



```
pi@LXFPics:~ $ sudo nano /etc/xdg/autostart/LXFCovers.desktop
```

Creating an autostart config will run the project code when Raspberry Pi OS starts.

If the user closes the PyGame window or presses the Esc key, **running** is updated to **False**, and the loop breaks, forcing PyGame to exit:

```
            for event in pygame.event.get():
                if event.type == pygame.QUIT or (event.type ==
pygame.KEYDOWN and event.key == pygame.K_
ESCAPE):
                    running = False
                    break
```

Outside of this **for** loop, but inside the **range(300)** **for** loop, we close that **for** loop by telling the code to wait for a second. Effectively, the **for** loop controls the timer, so by changing 300 to 120, we tell the code to wait two minutes before swapping the image:

```
            time.sleep(1)
```

The final line closes PyGame:

```
    pygame.quit()
```

Save the code as **show_covers.py** to a directory called **LXFPics**. Inside that directory also create a subdirectory called **covers**, and inside that, copy all of the **LXF** cover images.

To set the code as an executable file, open a terminal and navigate to **/home/Pi/LXFPics**, and run the following command:

```
$ chmod +x show_covers.py
```

The final part is where we set the code to autorun when Raspberry Pi OS boots. For this we need to create an autostart entry. Open a terminal and run the following command:

```
$ sudo nano /etc/xdg/autostart/LXFCovers.desktop
```

Inside the file, enter the following to autorun the code. When done, press Ctrl+X, then Y and Enter to save and exit:

```
[Desktop Entry]
Exec=/home/pi/LXFPics/show_covers.py
```

Reboot your Raspberry Pi and when it boots up, you will be greeted by an everlasting sequence of randomly chosen *Linux Format* covers. LXF

» THE END IS PI!

Les has covered Raspberry Pi news and projects since 2013 and he's seen the community grow around our favourite single-board computer. The Raspberry Pi community, like the Linux community, offers a plethora of exciting avenues to explore. We can use the Raspberry Pi as a low-power Linux PC, or we can create robots and artificial intelligence. Some choose to drop a Pi into an arcade cabinet so they can play retro games. That isn't even scratching the surface of what can be done with a Pi; you just need to break each part of the project down, and solve the problems as they occur.

The Pi and other single-board computers are tools with which we solve problems. For fun, for profit, for science, for others, we use the Pi! Les has built projects for fun (arcade cabinets, home cinema) and profit (a coin-operated fortune teller and the commentary system for a theme park racing ride. But behind all of these projects is failure.

Learning to FAIL (First Attempt In Learning) has been Les's mantra, taught to him by former Raspberry Pi director of education, Carrie-Anne Philbin when he worked at Picademy. You will fail, but use that failure to learn and grow yourself and your skills.

This may be the end of Les's work at *Linux Format,* but his Pi work will continue over at **Tomshardware.com**. They've got Raspberry Pi projects, tutorials and news every day of the week. So, head over and join them for more Raspberry Pi projects.

Linux: the essential learning library

Learning Linux skills has a problem: there are just so many tools and technologies to choose from. **Stuart Burns** is your guide to success.

The great thing about Linux is that it is inexpensive and you can get the skills from books such as those by Sander Van Vugt. These books cover what would be in the Linux administrator exam. RHEL certification is still the hot ticket.

Oracle offers a certification that is very similar to RHEL and covers Oracle Enterprise Linux. RHEL and OEL are extremely similar. The interesting thing is that the OEL exam is less than half the price of the RHEL one.

Unfortunately, very few Debian exams exist. There is the LPIC series of certifications but we have not known one person who held the LPIC certification. We would recommend this direction only if there is some explicit reason that RHEL certification isn't enough.

As companies prioritise automation, containerisation and scalable cloud-native infrastructure, Linux DevOps roles are central to modern IT operations. It's critical to build a focused skill set that marries with real-world tools and workflows. The trick is identifying those useful skills from the hype.

Bash Scripting

Shell scripting is key to automation in any Linux-based role. Being able to write simple but effective scripts to automate tasks saves time and reduces errors in repetitive operations. Pretty much every DevOps role need competency in writing and debugging *Bash* scripts.

Linux is a tool-building operating system. That means tools such as *sed, grep* and *awk* are well worth knowing alongside regular expressions. It may seem boring at first, difficult perhaps, but these are central to being a good admin. For the more advanced users, there is a free book at **https://github.com/dylanaraps/pure-bash-bible**.

Version control with Git

Every DevOps role requires using *Git*. You'll be expected to work with versioned infrastructure and deployment code, collaborate using *Git* branches, and contribute via pull requests. *Git* can be horrendously complex, depending on how deep you dig. Thankfully you don't need to know it all. Some areas to concentrate on include:

1. *Git* basics (clone, commit, push, pull)
2. Branching and merging
3. Rebasing, conflict resolution
4. Using *Git* in CI/CD pipelines

The great thing about *Git* is that it is free as in beer and even the most in-depth book is available for free, in a *Git* version-controlled form obviously, at **Git-scm.com** (**https://tinyurl.com/4ytsmsaw**)

People confuse *Git* and GitHub/GitLab but it's completely possible to do it locally. GitHub is free (for basic users) but for those wanting the true *Git* experience, downloading and running it locally can be a great way to learn. GUIs are great but understanding the why of the command line is equally important as the how.

Configuration management

Configuration management tools such as *Ansible* enable administrators to define infrastructure as code and automate system configuration across multiple servers. *Ansible* is widely used for its ease of use and agentless operation. Key areas to understand are:

1. Writing playbooks in YAML
2. Using variables, templates and roles
3. Running ad hoc commands and managing inventories

Git and *Ansible* go together like toast and jam. Any serious admin has their own workstation setup written in YAML and version controlled with *Git*. It takes a couple of hours once you know how. Then when you rebuild your system, it's a simple matter of installing *Ansible* and running your *Ansible* playbook, and within minutes your system is back to how it was before, with all the tweaks and packages. Keep the YAML file and repository on a remote server, not locally, for obvious reasons.

One extremely useful guide to *Ansible* is at **https://ansible.jeffgeerling.com**. We wholeheartedly recommend Jeff Geerling's *Ansible* books.

Docker and containerisation

DevOps engineers are expected to build and manage *Docker* containers regularly. All the different components can be daunting but with time it becomes easier. To be competent in *Docker*, you need to master the following:

1. Writing *Docker* files
2. Using *Docker Compose*
3. Building and managing images
4. Understanding container networking and volumes

Yet again, another easy and free technology, and one that will continue to pay dividends. Containers are the new virtualisation. They isolate applications from the host, effectively creating an application in a highly portable, easy-to-use, distro-agnostic format.

Most vendors now offer at least one containerised version of their application. The great thing is that once properly architected, upgrades becomes as trivial as downloading and running the new container.

This is one technology that will touch upon virtually every IT-related job, so getting up to speed is essential. We recommend Nigel Poulton's *Docker Deep Dive*. It's a thin book but it has all the important information.

Kubernetes

Kubernetes is now the standard for orchestrating containers at scale. Whether deploying microservices or managing infrastructure, *Kubernetes* knowledge is almost always required. Core concepts to learn include:

1. Pods, deployments, services
2. ConfigMaps, secrets, namespaces
3. Helm for package management
4. Working with *kubectl* and writing YAML configs

Terraform your code

Terraform lets you provision and manage cloud infrastructure using code. It's one of the most in-demand tools in DevOps today. Skills to build include:

1. Writing HCL to define infrastructure
2. Creating reusable modules
3. Managing state files
4. Working with cloud providers such as AWS, GCP or Azure

Continuous integration

DevOps engineers are responsible for designing and maintaining CI/CD pipelines to automate building, testing and deploying software. You need to learn:

1. Building pipelines using Jenkins, GitHub Actions or GitLab CI
2. Automating tests and deployments
3. Integrating with *Docker* and *Kubernetes*
4. Using webhooks and secrets

This is hard to quantify as there are many different CI/CD platforms to choose from and differentiating them is not easy. We'll leave this as an exercise in research.

Cloud platforms

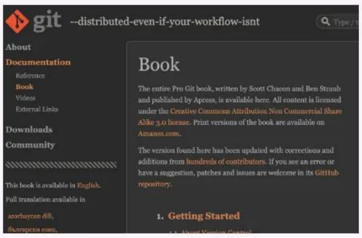
This is where there are real choices with real consequences. The major cloud platforms (Amazon, Google or Azure) have very capable offerings. The problem is that they are so huge that mastering all the platforms is practically impossible. They also cost an arm and a leg. If you want a cheap VM, these three are not the best options. That said, big employers love them…

You don't need to master every cloud provider, but basic proficiency in one (usually AWS) is important. That said, Microsoft offers £200 credit to anyone wanting to get started. But watch those costs like a hawk.

Your first role

To land your first DevOps role, focus less on collecting certifications and more on building real, demonstrable skills. Use your own projects or lab environments to deploy a containerised application, automate infrastructure with *Terraform*, or create a working CI/CD pipeline. These experiences will stand out to hiring managers and give you the confidence to perform in a professional setting.

Start simple, build consistently, and stay hands-on. Linux DevOps is a practical discipline – and the best way to learn it is by doing. **LXF**



Book

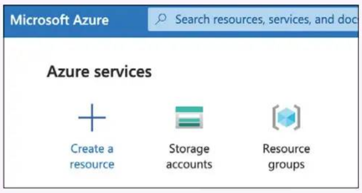
The entire Pro Git book, written by Scott Chacon and Ben Straub and published by Apress, is available here. All content is licensed under the Creative Commons Attribution Non Commercial Share Alike 3.0 license. Print versions of the book are available on Amazon.com.

The version found here has been updated with corrections and additions from hundreds of contributors. If you see an error or have a suggestion, patches and issues are welcome in its GitHub repository.

This book is available in English.

Full translation available in

Git isn't GitHub. It's completely acceptable to run it locally and this free book is one of the best resources available.



Azure: an extremely capable but very expensive cloud. Popular and easy to use.

Stuart Burns is a senior sysadmin for a Fortune 500 company in that there Londinium.

» BYE LINES

It is with not a small amount of sadness that I write this last sysadmin column for *Linux Format*. Fifteen years ago, it was **LXF** that provided my first foray into commercial writing, an adventure that took me to many unexpected places and provided me with many engaging experiences.

In my final column, I want to share a view of how the future of Linux and system administration may evolve and how you can ride the wave. As they say, the only constant is change.

Without a doubt, there will be a massive amount of AI involved in any future computing. AI can be useful if you know what you are doing. Writing a *Bash* script can be reduced from half a day to 20 minutes. The important thing is understanding the AI output, because I can assure you it isn't always correct.

Luckily, unlike Windows, I seriously doubt any Linux distro will start trying to stuff AI enhancements down on to your desktop. In desktop computing, Linux will continue to be a small player. In the cloud and server computing environment, it will continue to explode.

In areas such as HPC, AI and containerisation, it will go from strength to strength. No right-thinking sysadmin would choose Windows for such purposes.

In the main body of the article, I discuss some of the technologies that are going to be key over the next few years and how you can learn them effectively, inefficiently and hopefully inexpensively.

It truly is the end of an era and who knows what the future will bring? In the words of Douglas Adams, "So long, and thanks for all the fish!"

COOL RETRO TERM

Credit: https://github.com/Swordfish90/cool-retro-term

Cool terminals

Shashank Sharma is not one for nostalgia or reminiscing about the good ol' days, but he's all for it if you can do it with style and pizzazz.

OUR EXPERT

Shashank Sharma has interacted with some incredible folks over the last 16 years writing for **LXF**, without meeting them, regrettably, and now his watch is ended.

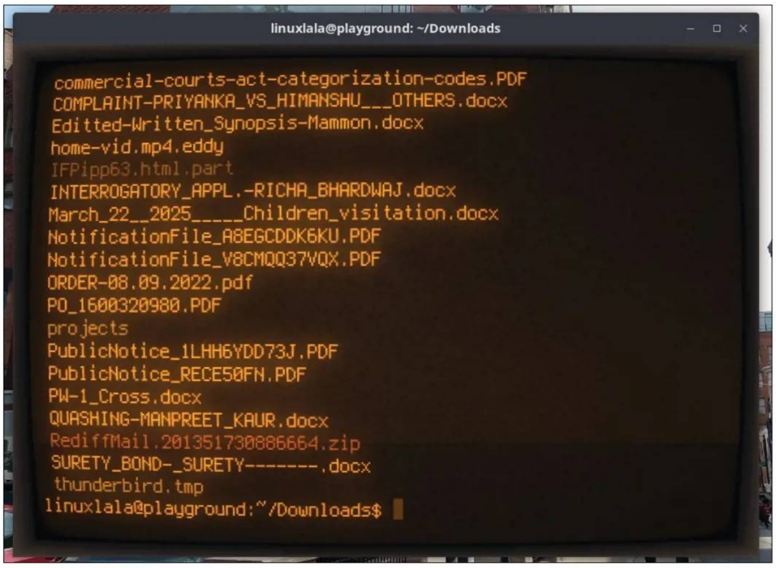
A lot can happen over a quarter of a century. In 2000, *The Matrix* was still on everyone's mind, more so than the Y2K bug even. *Harry Potter* was merely a book series, with the best yet to come, the *LoTR* films hadn't been released, a smartphone was still a PDA, and looked at with disdain, and we were inching ever so closer to the year of the Linux desktop, which was all the more reason for the launch of one of the most popular magazines dedicated to Linux and open source software. Now, in 2025, the *Harry Potter* series is on the verge of a reboot, the smartphone is everywhere and PDA is merely a display of affection, and the year of the Linux desktop is still awaited. But when it comes, you won't read about it in the pages of this wondrous magazine.

However, if you ever wonder what computer screens looked like back in the day, *Cool Retro Term* is one way to find out. For one, unlike the slim screens of today, computer monitors back then were hefty, heavy machines. *Cool Retro Term* is a terminal emulator that excellently mimics the look and feel of the old CRT monitors.

This author had originally planned to feature *Cool Retro Term* more than two years ago, but kept kicking the can down the road, in favour of other projects. When informed about the 25th anniversary issue of *Linux Format,* the first instinct was to feature a suitably classical project that had been around for at least 20-25 years. *Mutt* and *Midnight Commander* came to mind naturally.

But we've decided to have a bit of fun for our last hurrah, and that brings us to *Cool Retro Term.* The project is quite popular, so you'll find it in the software repositories of just about all desktop distros. This means installing it only requires running the `sudo apt install cool-retro-term` command on DEB-based distros, or `sudo dnf install cool-retro-term` if you're on a RPM-based distro instead.

Along with *Cool Retro Term,* and keeping in line with the final issue of **LXF**, we'll also discuss another popular project that although no longer in development, is still missed and fondly remembered. Refer to the box for more details about *eDEX-UI,* one the most eye-pleasing terminal emulators ever.



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thunderbird.tmp
linuxlala@playground:~/Downloads$
```

Cool Retro Term devotes its energies towards providing a visual experience rather than being a fully-featured terminal emulator.

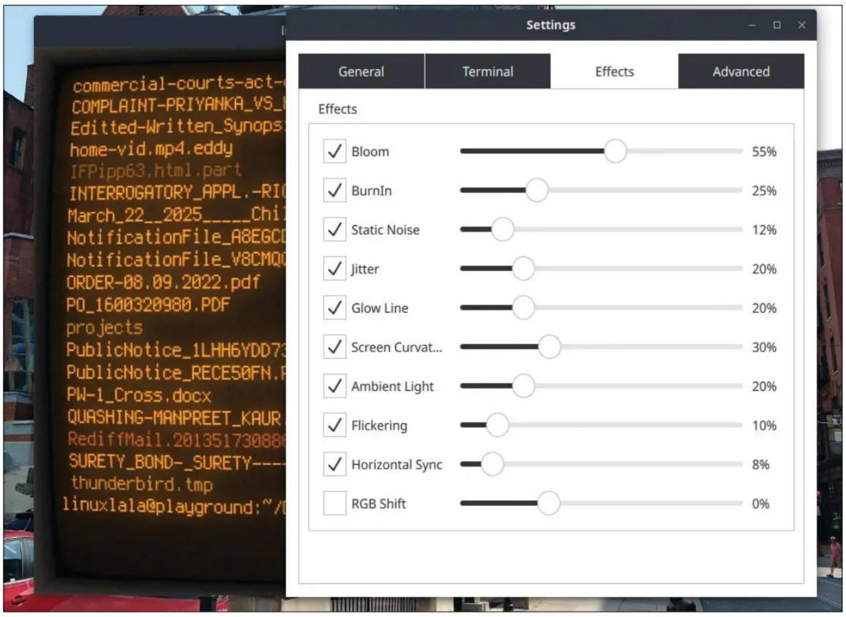
Caution: Nostalgia ahead

Back in the day, like when this author first installed Slackware on a Pentium 166MHz PC in 1996, one had to manually enter the vertical and horizontal refresh rates for your monitor. An incorrect configuration could result in a wobbly picture with flicker on the screen that would make your eyes water. This effect is on full display when you first launch *Cool Retro Term.*

You'll find a bulk of its settings devoted towards tweaking its appearance for the retro look.

The default interface presents a curved display featuring a monochrome amber screen with bright orange colour for the text. The font size is unbearably large to eyes that have grown accustomed to LCD screens. You'll also notice, or become unnerved by, the glow line, a descending horizontal line that traverses the entire display. The entire background has a snowy effect, which, along with the glow line, was fairly common on poorly configured or really old monitors. Each of these effects and more and be adjusted from the Settings window.

The default *Cool Retro Term* interface doesn't feature a menu bar, so right-click anywhere in the window to access the context menu and click View > Show Menubar. In our opinion, the menu bar distracts



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SURETY_BOND-_SURETY---
thunderbird.tmp
linuxlala@playground:~/
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☑ Bloom 55%
☑ BurnIn 25%
☑ Static Noise 12%
☑ Jitter 20%
☑ Glow Line 20%
☑ Screen Curvat... 30%
☑ Ambient Light 20%
☑ Flickering 10%
☑ Horizontal Sync 8%
☐ RGB Shift 0%

Find an elderly neighbour or grandpa, and you could transport them through time with Cool Retro Term.

from the visual treat that is *Cool Retro Term*, but you can try it for yourself. If the default Amber appearance is not to your liking, right-click in the interface and select something else under Profiles. Your choices are IBM DOS, Futuristic, Green Scanlines, Vintage and so on. You can also click View > Zoom Out in the right-click context menu if the default font size appears too big. You'll have to manually repeat the procedure as there are no defined keyboard shortcuts.

Personalisation

The Settings window features four tabs that offer a number of parameters that affect the appearance of *Cool Retro Term*. Under the default General tab, you can switch to a different profile, or define the Opacity, Brightness or Contrast. The Terminal tab is home to additional Font settings. We have enabled the Blinking Cursor from under the Terminal tab.

Various parameters are dependent on the prowess of your hardware, and you'll find these listed under the Performance heading under the Advanced tab. You can change the Texture, Bloom or BurnIn quality, for instance, using the slider scale. The changes take effect in real time, so you can just move the Settings window to the side, and start making changes. You'll be able to see the effect they have on *Cool Retro Term* in real time.

All the effects that are used to provide the nostalgic appearance of *Cool Retro Term* are housed under the Effects tab. These include the Bloom, which is set at 55% by default. At 12%, the Static Noise is definitely noticeable, but not a nuisance. Use the slider scale to increase it to over 50% and you'll see just how efficient *Cool Retro Term* is at providing a realistic feel. You can similarly play around with the Jitter and Glow Line effects.

Cool Retro Term defaults to a 30% screen curvature, but you can tweak this, too, or even turn it off entirely if you so prefer. The Flickering and Horizontal Sync are two additional effects that you can tweak to great joy. Along with the sounds of a dial-up-internet modem and a dot-matrix printer, these visual effects are all a reminder of what computing used to be like a few decades ago.

Unlike other terminal emulators, *Cool Retro Term* doesn't feature a shortcut for opening another instance, and it also isn't a tiling terminal emulator, like alternatives such as *Tilix*. Despite the limited feature set, however, you can use *Cool Retro Term* for work, depending on how frequently and for what purposes you use the Linux CLI. By no stretch is it an alternative to your preferred terminal emulator, nor does it aspire to be one. But much like this magazine, it's fun to spend time with. **LXF**

QUICK TIP

Since we won't get any future attempts to do so, let us take a moment to mention a wonderful project that we wished to feature in an upcoming issue. We've talked about the *Pip* package manager for installing Python packages, but our new favourite is *UV*, an incredibly fast and robust Python package manager, written in Rust.

» TERMINAL EYE CANDY

One doesn't normally think of the CLI or a terminal emulator when one hears the words eye candy. But that's what was on offer with *eDEX-UI*, a full-screen, touch-friendly terminal emulator and system monitor that looked and felt straight out of a sci-fi movie.

Inspired by the board room sequence in 2010's *Tron: Legacy*, film, the *eDEX-UI* terminal emulator was designed to bring a sci-fi-like UX to the desktop, while retaining functionality.

Unfortunately, the project shuttered in 2021 with version 2.2.8, and you won't find it in the software repositories of popular desktop distros today. But thankfully, you can grab the AppImage from the project's GitHub page (**https://github.com/GitSquared/edex-ui**) to try it out for yourself.

Set the downloaded AppImage as executable with the `chmod +x eDEX-UI-Linux-x86_64.AppImage` command. Depending on your distro, you might have to use *sudo* to run it with the `sudo ./eDEX-UI-Linux-x86_64.AppImage --no-sandbox` command.

You'll notice the clock on the top-left of the screen with a system monitor under it. The bottom-left displays the filesystem, and you can easily double-click to navigate into directories. The right of the screen shows network traffic, and there's a keyboard at the bottom for you to type in your commands and operations.

It's a shame that no particular effort has ever been made to bring such UX to the mainstream, but at least you can still experience its brilliance.

GIMP

Credit: www.gimp.org

Edit photos like a professional in GIMP 3

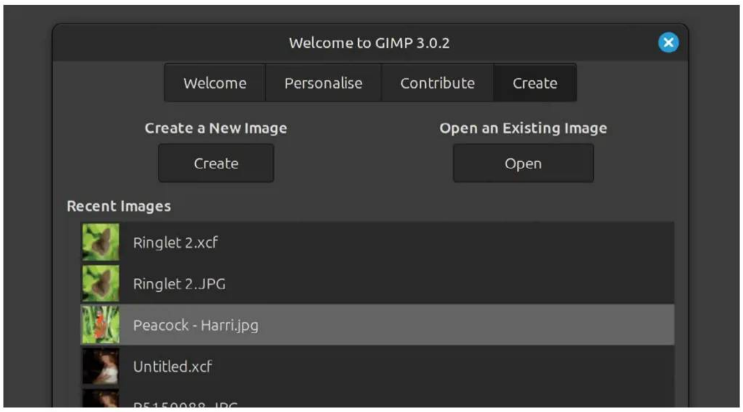
Shutterbug **Nick Peers** reveals how to use GIMP's new and improved tools to take your photos to the next level.

OUR EXPERT

Nick Peers has a mountain of photos new, old and ancient to plough through at some point. *GIMP* might be just the tool he's looking for.

Think image editing and there's one application that stands head and shoulders above every other: *GIMP*. The venerable image editor continues to evolve and improve, and final version 3.0 is the best release yet. Not only do you gain support for non-destructive filters, which is a game changer for image editing and manipulation, but there are also numerous improvements to the app's user interface and workflows, as well as native Wayland support and an updated *GTK3* interface that scales beautifully on 4K screens.

In this tutorial, we explore its many new features, plus reveal how to use it primarily as a tool for editing your photos.



GIMP's new splash screen makes it easy to revisit previously opened photos – you can also tweak certain preferences.

Update to GIMP 3.0

Ubuntu users will find the latest version of *GIMP* is available through the *App Center* as a Snap package (*GIMP 3.0* is also available through Ubuntu 25.04's default repositories); Mint users should select the Flatpak version through *Software Manager*. You can also download a portable AppImage through the *GIMP* website (**www.gimp.org/downloads**).

Once updated or installed, you're ready to launch *GIMP*. If you're a first-time user, it's relatively straightforward to navigate, while existing users will find everything's familiar. New in version 3 is a welcome dialog, which opens to a splash screen providing links to the website, tutorials and general documentation.

The dialog offers three further tabs: Personalise enables you to make quick adjustments to the user interface. You can switch between three basic colour schemes, plus change icons from the default to a legacy set from an earlier release. The default set is monochromatic – flick Use Symbolic Icons If Available to Off if you'd rather they were multicoloured.

You'll also see controls for overriding the default icon and font scaling settings – of most use to those using 4K displays – along with an option for changing the language, plus a couple of toggle-based switches to merge the menu and title bar and toggling tool groups on or off as required. All changes (except where noted) are applied instantly.

The Contribute tab is where you can send bug reports, volunteer your time on the project as a coder or translator, or donate to help fund development.

Last, but by no means least (as it's the tab *GIMP* defaults to on all subsequent startups), there's the Create tab. Initially this provides simple Create and Open buttons for starting from scratch or opening an existing image. Going forward, you'll also see a Recent Images list of all those images you previously opened.

Editing photos

We're going to focus on making changes to existing photos rather than explore *GIMP's* image creation and painting tools. Clicking Open to browse for and select an image to work on; *GIMP* supports all major formats.

Once imported, press Ctrl+S to save the image and you'll see it prompts you to save it in *GIMP's* own XCF format. Think of this as your first experience with *GIMP's* non-destructive tools – when your image is ready to share, choose File > Export to save it in a universal format (PNG by default, JPEG and other options are found behind Select File Type). Saving in XCF format also ensures you can't accidentally overwrite your original photo.

You'll see the image appear in the centre of the screen with panels to either side. Start with the left-

QUICK TIP

If you installed *GIMP* through Ubuntu's system repositories and want to upgrade without losing all your settings and customisations, visit https://ubuntuhandbook.org/index.php/2024/11/install-gimp-3-ubuntu/ for details of adding an unofficial PPA.

hand panel, where you'll see icons representing *GIMP's* tools. It's not immediately obvious, but these represent tool groups, each one comprising one or more tools with just the primary tool on display.

Roll your mouse over each icon to reveal a pop-up. This provides a description, key shortcut (if it exists) and a list of other tools in the group. Click an icon to select the primary tool, or right-click it to switch to another tool in the group.

Once a tool is selected, you'll see a series of options related to that tool appear beneath the icons. It's here you can fine-tune the tool to your needs – for example, when using the colour selection tool, you can set a selection threshold (the higher the threshold, the more colours are selected alongside the primary colour when you click on the image to select part of it).

All these tools work as they do in other image editors – the simplest way to get going with each one is with the help of the manual. Press F1 and you are told the manual is missing, but that you can read it online in your browser. Click OK to do so. Going forward, you can also make use of the context-sensitive help; press Shift+F1 and you'll see the cursor change to a question mark icon. Click the relevant area – such as a tool, the brushes or the main window – and *GIMP* takes you straight to the relevant chapter in its online documentation.

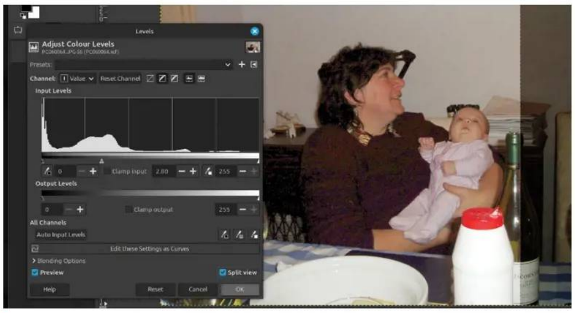
New layer effects

Most people use image editors to try to correct issues with their photos. Let's start with a common problem: images that are too bright or too dark. *GIMP* offers a range of tools for fixing this, and it pays to explore them in turn to see which one offers the best results for a specific situation.

In doing so, you'll encounter *GIMP 3.0's* standout feature: layer effects. In the past, applying a tool or filter to an image was a permanent fix, whereby the original image was irrevocably altered as a result. *GIMP 3.0* changes this by using non-destructive effects. Instead of applying directly to the image, they sit separately, enabling you to toggle them on and off at will, combine multiple layer effects and revisit them later with further tweaks – all without touching the underlying image.

(Note, you can still apply changes to the image directly as before – look for the Merge Filter checkbox when you've selected a tool. Ticking this applies the edit directly to the image.)

Let's illustrate a practical use for this by applying a range of different lighting corrections to the same image, then toggling them on and off at will, enabling us to compare the effects of each directly to find the best one for the job.



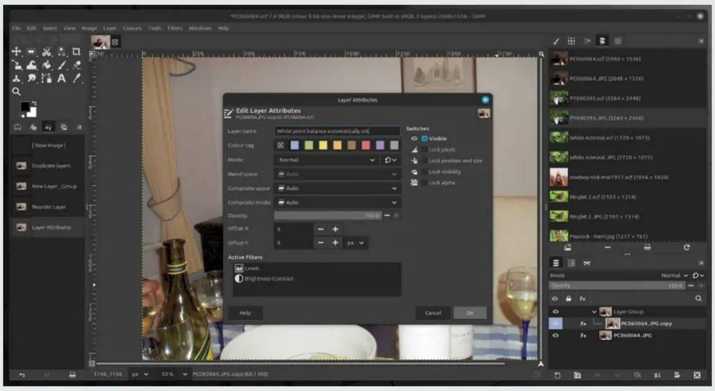
Avoid the Brightness-Contrast tool when attempting to correct poorly lit photos – the Levels tool is far more effective.

» WORK WITH LAYERS

While *GIMP's* switch to non-destructive layer effects makes it easier than ever to edit your photos, there will still be times when you want to work with layers. Think of layers like translucent sheets you place on top of the original background layer.

As shown in the main text, you can also duplicate existing layers to perform edits on that layer without affecting the original underlying image. Each layer is then visible from the Layers panel in the bottom-right. You can rearrange layers by clicking and dragging them into the desired order, plus double-click the layer's title to rename it, or double-click the thumbnail to access its attributes. Here you can lock selective elements, make it semi-translucent so the layers beneath peek through, and change mode so it blends with the layer beneath.

If you add large numbers of layers, you can also organise them into groups, to make them easier to manage. Right-click on a layer and choose New Layer Group, then drag existing layers into that group. You can then move all the layers together by dragging and dropping the group into the desired order.



GIMP retains support for multiple layers even with its non-destructive layer effects.

Fix lighting issues

Start by opening an image that suffers from underexposure or lack of light. Next, open the Colours menu, where you'll find various lighting correction tools. The obvious one to start with is Brightness-Contrast. This opens a simple dialog with two sliders, one for each setting. It's somewhat crude – as you push the Brightness slider up, the levels increase, but the image becomes washed out, forcing you to push the Contrast slider up in turn. Push this too far, however, and the image blacks out.

Beneath this is a Blending Options section – expand this to reveal an Opacity slider and a Mode setting with dozens of options. Experiment with each to see the effects they have on your image.

As we said, the tool is somewhat crude, and *GIMP* offers better. It even suggests a superior alternative within the dialog – Edit These Settings As Levels – which, if clicked, opens the next dialog we're going to try. However, for now, ignore this, and try to get the best possible image you can before clicking OK.

Toggle layer effects on and off

Now look at the bottom of the right-hand pane, where you'll see the Layers dialog listing all the layers of your

QUICK TIP

Previous versions of *GIMP* ran in multiple windows, with each panel in its own floating window that could be moved and resized as desired. The single-window approach keeps things tidy, but you can switch back via the Windows menu – simply untick Single-Window Mode.

»

QUICK TIP

You can apply the same layer effect more than once (for example, to set black and white points in the image independently). They appear with the same name – Levels – in the Layer Effects panel, with the most recently applied effect at the top of the list.

photo (just the one in this case). Next to the thumbnail is an FX button – click this to reveal the Layer Effects pop-up. You'll see your Brightness-Contrast effect is listed with an eye icon next to it, indicating it's currently visible. Click this and the layer's effects magically vanish to reveal the original image underneath.

For more on the Layer Effects panel – including how to use it to manage your various layers – check out the annotation *(opposite).*

Now choose Colours > Levels to reveal a histogram of your image, which measures the amount of light across your image by displaying the amount of black, grey and white in it as a bar chart. Beneath the chart is a slider with three markers on the left (black), middle (grey) and right (white).

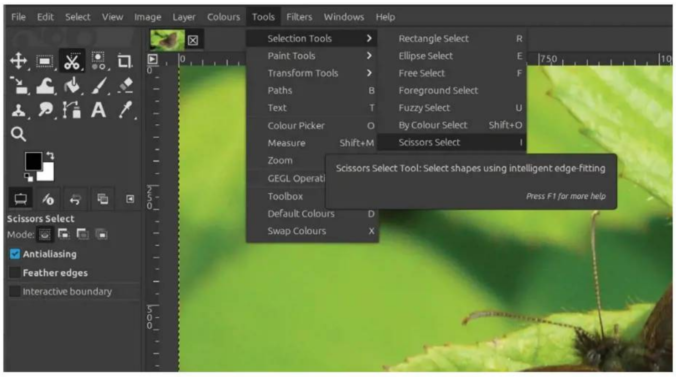
Start by dragging the middle slider to the left to brighten the image, or to the right to darken it. You'll notice how it's immediately more effective than the Brightness-Contrast tool. Also experiment with moving the left (dark) and right (light) sliders. Beneath this are further settings, including Output Levels. You'll also see an Auto Input Levels button that attempts to quickly correct the levels with a single click as well as dropper buttons for manually selecting black, white and midpoint parts of the image.

When working with a dialog, *GIMP* automatically applies a preview to the image so you can see the outcome of your effect or filter in real time. You'll also see a Split View checkbox – ticking this enables you to compare before (right of the vertical line) and after views of the image. Again, click OK to apply the filter non-destructively – it appears in the Layer Effects pop-up, and can be turned on and off like the original effect.

Keep experimenting

The Levels tool is far more effective than Brightness-Contrast, but *GIMP* offers other lighting correction tools, too. Curves enables you to define more midpoints on the line between black and white, and adjust its shape, but it can take more work. Shadows-

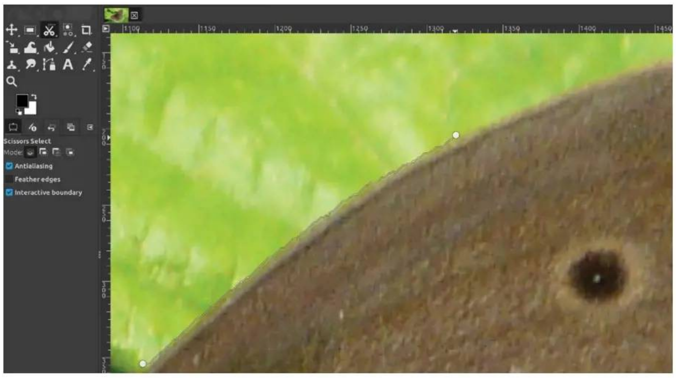
SMART SELECTIONS



Scissors Select Tool: Select shapes using intelligent edge-fitting

Press F1 for more help

☑ Antialiasing
☐ Feather edges
☐ Interactive boundary



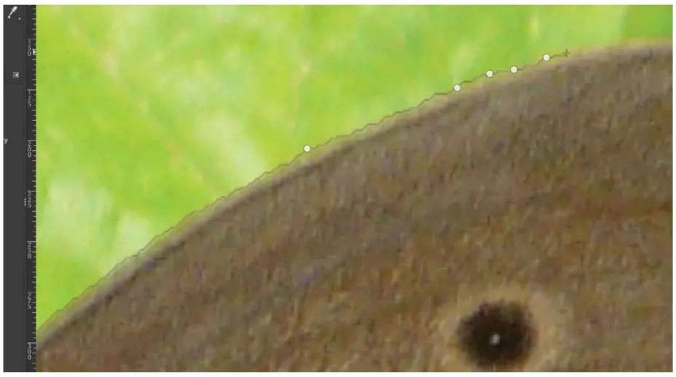
☑ Antialiasing
☐ Feather edges
☑ Interactive boundary

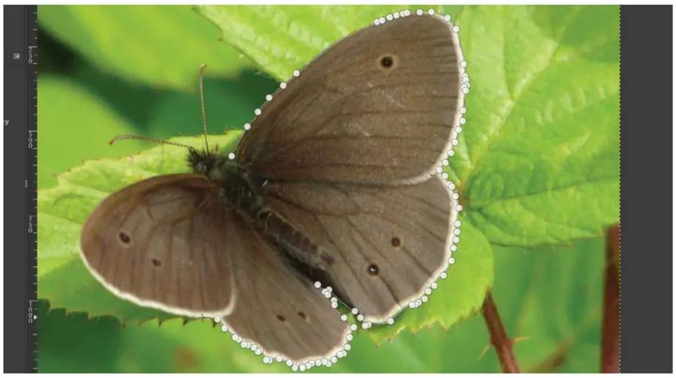
1 Select Scissors tool

When it comes to selecting irregularly shaped objects in an image, you have a choice of two selection tools: Scissors Select and Path. Path is more accurate, but it takes longer to use, so let's examine the Scissors tool in more depth. First, you need to select it either by navigating to Tools > Selection Tools or by pressing the I key.

2 Start tracing

Before you start using the tool, make sure Interactive Boundary is ticked under Tool Options on the left. Now click somewhere on the edge of the object you wish to select. You'll see a circle appear. Now place the cursor further along the object's edge and click again to set another control point. In an ideal world, a neat line is drawn along the edge.





3 Correct the line

If the line isn't smooth, delete the second control point (press Backspace) and try again, this time, keeping the mouse button depressed after clicking. The line is shown in yellow, and you can drag the pointer around to try to produce a smoother line – try shortening the distance between the two points where there's little contrast between object and background.

4 Complete your selection

Continue adding points. Once you've reached the final point, click on the original point to join everything up. You can make subtle tweaks by clicking and dragging on existing points to make changes or click on part of the line to add new points (hold Shift as you click to delete a point). Once complete, press Enter to convert it into a selection.

Highlights is another favourite, enabling you to bring out more detail using a pair of sliders that focus on accentuating the lighter (highlights) and darker (shadows) part of your image at the same time. There are also auto-correct tools under Colours > Auto, but note that these are applied directly to the image – they're not available as separate layer effects.

The Colours menu – as you'd expect given its name – is also the place to go when looking to improve the colour balance of images. There are several tools here that enable you to alter the balance by tweaking individual colours, but they can be tricky to get right. A simpler – but still effective – tool is Colours > Saturation, which provides you with a single Scale slider that can be used to subtly reduce or increase the temperature by altering the blue/red/yellow balance.

Combine tools

Many old photos have faded over time, but thanks to *GIMP's* White Balance tool, you can restore them to something approaching their original quality using a combination of tools. You can apply a quick fix – Colours > Auto > White Balance – but this is applied directly to the image rather than as a layer effect.

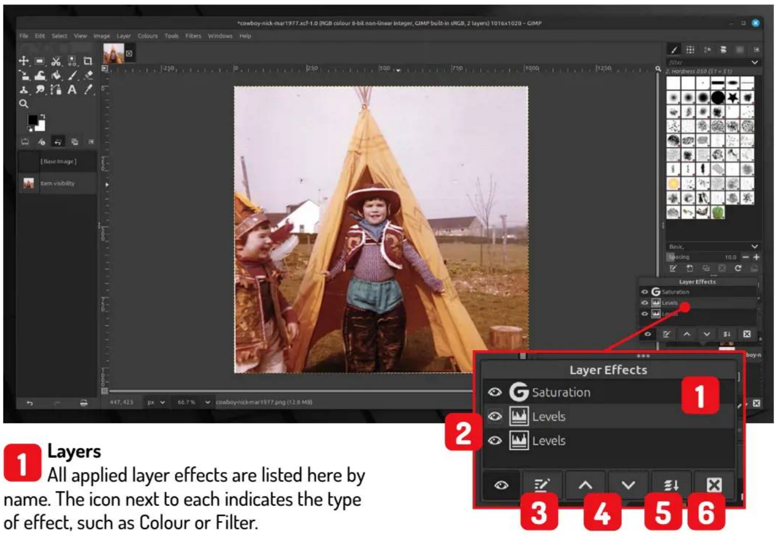
To make the changes non-destructive, you have to apply them manually. This involves opening Colours > Levels as before, and using the white point picker to select a part of the image you know to be white. You should see the rest of the image adapt. It won't be as good as the automatic effect, but you might be able to get close by selecting the black point picker to highlight the darkest part of the image, too.

Once you've applied one or both balances, you should find the image is much closer to how it would have originally looked. Try pairing this with the Colours > Saturation tool if the colours are now too vivid (try nudging the slider to somewhere between 0.800 and 0.600 to tone down an overly red image, for example). Or try Colours > Colour Balance for even more control – here you can manually adjust colour levels using cyan, magenta and yellow sliders in conjunction with options to limit your adjustment range to just the shadows, midtones or highlights. Use the Opacity slider to weaken the effect by making it more transparent.

Keep on tweaking

Take the time to explore *GIMP's* other tools – check back to **LXF323** for even more tips. One area to focus on is the selection tools, which enable you to isolate parts of the image to either work on or ignore. One of the most effective is the Scissors Select tool – see how it works in the step-by-step guide *(opposite)*. **LXF**

MANAGE LAYER EFFECTS



1 Layers
All applied layer effects are listed here by name. The icon next to each indicates the type of effect, such as Colour or Filter.

2 Layer visibility
The eye icon next to each layer indicates whether it's visible or not. Click here to toggle the layer's visibility.

3 Edit filters
Click this button to open the Editing Filter dialog for the selected filter to make further tweaks.

4 Rearrange layer order
Layer filters work in the same way as regular layers – use these buttons to rearrange their order.

5 Merge all effects
Click this to apply all visible filter effects directly to the image once you're happy you've achieved your desired result.

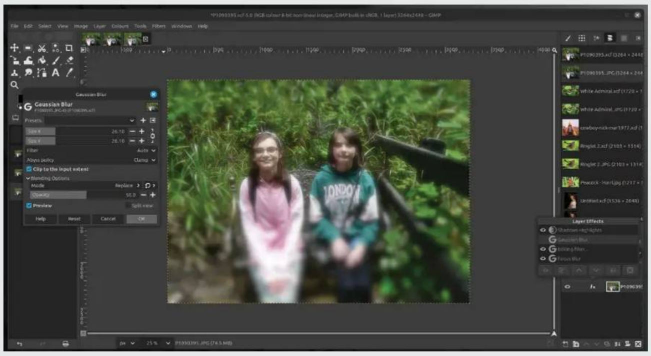
6 Remove unwanted filter
Click this to delete the currently selected filter. No other filters are affected.

» PLAY WITH FILTERS

GIMP's Layer Effects feature also extends to filters, which can be used to apply striking effects to your images – such as Gaussian Blur, a fake photo frame or a range of artistic filters from cartoon to oil painting. These are all non-destructive, and you can mix and match them as you like. Just play around with the controls for each to see what you can do.

There are also some filters that serve a more practical benefit. Many of these can be found under Filters > Enhance, like the Sharpen (Unsharp Mask) filter, which does a good job of sharpening slightly out-of-focus or blurry images. There's also a tool for removing red eye from images – this works by first selecting the area around your red eye or eyes, then applying the filter (otherwise it's applied to the entire image).

Sadly, these more practical filters can't (yet) be applied as layer effects, so you should either save a copy of your image prior to applying them, or right-click the layer and choose Duplicate Layers to create an exact copy (with non-destructive layer effects also copied) to experiment with. Double-click the layer title to rename it to match the filter you apply to help identify it going forward. Use the visibility toggle to choose which layer to show prior to exporting a copy.



Not all filters support layer effects, but many do, including Gaussian Blur and Focus Blur, as used in this example.

ELECTERM

Credit: https://github.com/electerm/electerm

Retro fix: Dial in to the bulletin board scene

Before the internet, there was an earlier dial-up network where people could communicate. **Michael Reed** investigates this retro online scene.

OUR EXPERT

Michael Reed was 2:2502/11.2 on the local (Hull) FidoNet scene, a keen BBS user in his youth!

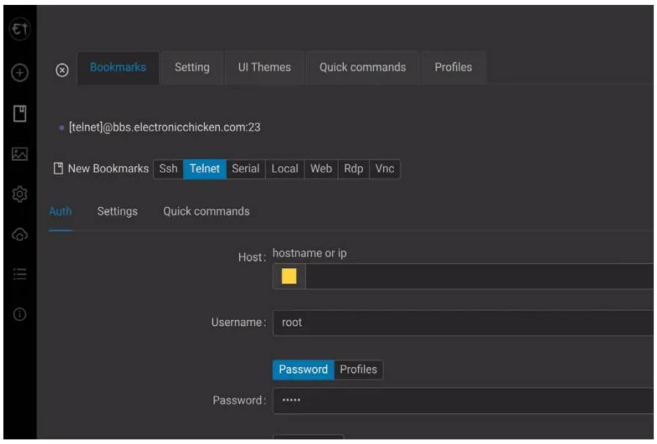
It's difficult to say exactly when the internet was born as it evolved from an earlier set of networks and protocols. However, other networks evolved in parallel. Before most people had heard of the internet, some hobbyists used a modem to connect to a computer running a bulletin board system (BBS). Let's have some fun and see how you can still play around with these systems and how they worked.

By the mid-'80s, if you had a home computer and modem, you'd be spoiled for choice, as nearly every town had BBS systems that you could dial up and connect to. Typically, they offered an interactive text-mode interface, and later they featured colourful block graphics using a system called ANSI.

What could you do on such a system? Once you had connected and logged in, you could read news bulletins, download and upload files, and interact on the forums. FidoNet was the most popular of these forum systems, and it used a network of BBSes to pass the messages from one system to another, meaning that in the '80s and '90s, you could engage in conversations with fellow nerds around the world.

For many, BBSes led to their first experience with Linux. If you were willing to block up your phone line for multiple nights, you could download a Linux floppy disk set, and use the forums to find out how to use it.

The explosion of cheap internet dial-up access in the mid-'90s largely killed off the bulletin board scene, but there are still a few BBSes up and running that you can connect to now (ironically) via the internet. You can even set up your own BBS if you want to.



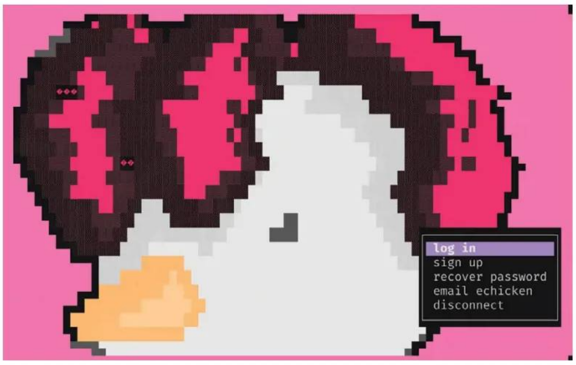
[telnet]@bbs.electronicchicken.com:23

Host: hostname or ip

Username: root

Password: •••••

Electerm is a modern app that allows connection to BBS systems via Telnet.



```
log in
sign up
recover password
email echicken
disconnect
```

Logging into the Electronic Chicken BBS with a username and password.

The history of the BBS

Early on in the history of computing, people started connecting computers together. The dumb terminal was part of the landscape in the mainframe era of the '70s, for example. Due to the awesome cost of huge mainframes, it made sense to give access to multiple users at once. A dumb terminal is a keyboard and a display mixed with a modicum of computing power and not much else. Like Linux, mainframe OSes of the '70s typically had multi-user and timeshare facilities, so more than one terminal could be connected at once.

Once the people managing the computers had multiple users in the same building accessing a larger, server computer, the next step was to implement access from outside. This is where the modem (MODulator/DEModulator) came in. A modem does two things: it converts computer data into an audio signal that can be transmitted over a phone line, and it converts such an audio signal back into computer data. With computer resources being scarce and expensive, it made sense to offer mainframe services to sites equipped with just a modem and a dumb terminal.

When home computers became affordable, modems for home users appeared on the market. If you connected via a modem and phone line, you didn't need a powerful computer; anything with a text-mode display, keyboard and serial port could be used.

Linux didn't start to gain popularity until the mid-'90s, but before that, you could use a modest home computer to connect to a Unix system. For example, a university might offer students text-mode shell access from home via a modem. That student might have access to programs such as a mail reader and even development tools such as a text editor and compiler.

With a mid-'80s home computer setup, a modem and a terminal emulator program, you could ring the telephone number of another computer that was set up in a similar way. What you could do from there was typically limited to text chat with the other computer user and file upload/download. To make the most of having a modem, you would want to connect to a BBS.

Bulletin board systems

A BBS is a type of server software. A home user, using terminal emulation software and a modem, would dial the phone number of the BBS computer. Unlike the client-side computer, the computer running the BBS software would have to be reasonably powerful, typically having a hard disk drive and sufficient memory and processing power to run a BBS, quite a lot of hardware by the standards of '80s home computers.

For most of the classic BBS era, the most common platform was a DOS-based PC, but most platforms had BBS software of some kind. A Unix-style operating system like Linux might seem to be ideal for hosting a BBS, but the truth is that Unix systems were expensive, difficult to use and not very common among home users until the late '90s and the Linux revolution.

The majority of these BBS systems would be located in the home of an enthusiast (called the sysop, the SYStem OPerator), and for this reason they tended to revolve around a theme. Every individual BBS would be packed with individual character. It would be quite common to find a BBS that was dedicated to a subject such as science fiction or gaming, or a platform such as the Commodore Amiga, or a local region.

Dialing in

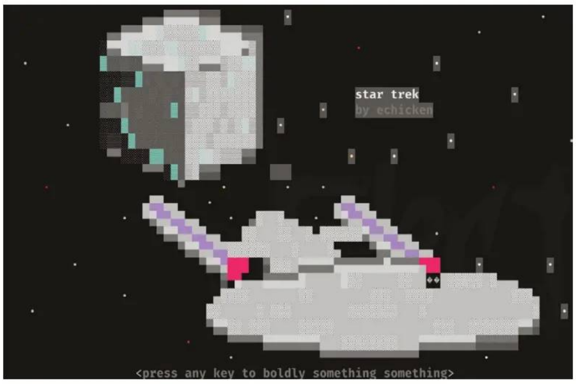
To connect to a BBS, you would load up the terminal emulation software on your computer. *Terminator* was a popular DOS piece of software, and *Term* was a well-known terminal emulator for the Commodore Amiga range of computers, to give just two examples. By the mid-'80s, most modems could dial the number, and you'd typically select the BBS from a list in the software. You might see a mention of an interesting-looking BBS in a magazine and want to try it out, or even see a BBS mentioned on another BBS. The software would dial the phone number, and if the line was unoccupied, you would be connected.

The interface would be text mode, but by the late '80s, most BBSes used colourful ANSI graphics and text to create a tailored, characterful experience for the visitor. Within the limitations of ANSI, every BBS would have its own look.

Typically, the interface would be controlled by key commands displayed on screen. So, once logged in, hitting M might take you to the messages screen, where you could read your messages, and pressing G would navigate you to the games page. It was an easy-to-use interface and was established long before most people had even heard of the World Wide Web.

What were they for?

Apogee Software is a publisher and developer that was formed in 1987. The company is well remembered for publishing classic DOS games such as the *Duke Nukem* series and 3D shooter *Terminal Velocity* under the shareware model, and the company was an early adopter of BBSes for distribution. US-based users could call the official Apogee BBS using the modem,



Doing a bit of BBS-based gaming. On a multi-line BBS, this might have been your first taste of multiplayer gaming.

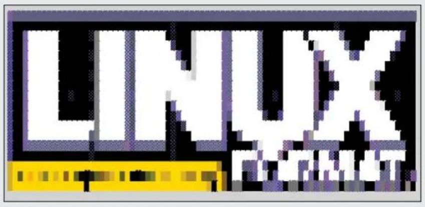
QUICK TIP

As you were going through lists of BBSes at night, you might occasionally dial a wrong number. Cue a buttock-clenching moment when a human voice came through the speaker.

» ANSI GRAPHICS

By around the mid '80s, most BBSes used a standard called ANSI to display a combination of text and graphics. When a terminal that understands ANSI sees an escape code, it interprets the following character sequence as a set of graphics commands. This makes it ideal for transmitting colour graphics and text over a low-bandwidth text connection.

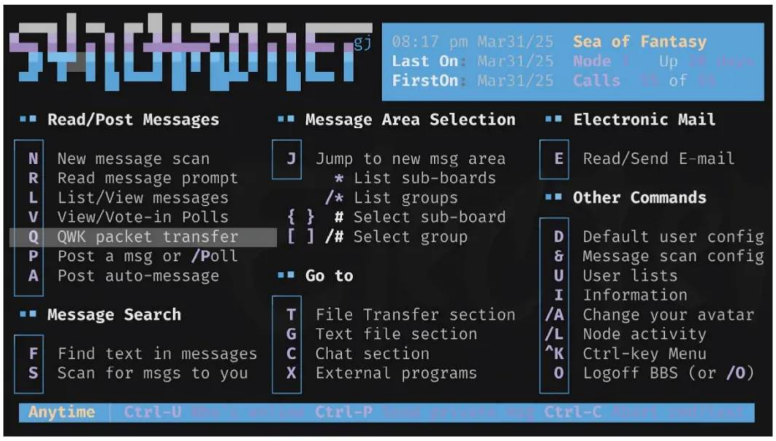
ANSI graphics consist of 16 colours with character-based block graphics. It's hard to be precise about the resolution as there are full-colour blocks, but there are corner blocks and dithered blocks, too. ANSI allowed the sysop to craft a unique graphical look for each BBS.



The LXF logo rendered as ANSI art using the converter at https://manytools.org/hacker-tools.

There were other, rival standards. Before ANSI became the standard, there were pure ASCII text-based services, and some BBSes favoured standards tied to the computer that was used on systems from manufacturers such as IBM (Code page 437) or Commodore (PETSCII). Some of those computers weren't powerful enough to emulate the character set of a different system. Prestel was a commercial service that offered online access from 1979 onwards in the UK. This used a different graphical standard called viewdata that had a look similar to TV-based Teletext services such as Ceefax.

»



```
SYNCHRONET                  08:17 pm Mar31/25  Sea of Fantasy
                            Last On: Mar31/25  Node       Up
                            FirstOn: Mar31/25  Calls      of

■■ Read/Post Messages       ■■ Message Area Selection   ■■ Electronic Mail

 N  New message scan         J  Jump to new msg area     E  Read/Send E-mail
 R  Read message prompt         * List sub-boards
 L  List/View messages         /* List groups           ■■ Other Commands
 V  View/Vote-in Polls      { }  # Select sub-board
 Q  QWK packet transfer     [ ] /# Select group          D  Default user config
 P  Post a msg or /Poll                                  &  Message scan config
 A  Post auto-message       ■■ Go to                     U  User lists
                                                         I  Information
■■ Message Search            T  File Transfer section   /A  Change your avatar
                             G  Text file section       /L  Node activity
 F  Find text in messages    C  Chat section            ^K  Ctrl-key Menu
 S  Scan for msgs to you     X  External programs        O  Logoff BBS (or /O)

 Anytime | Ctrl-U                Ctrl-P                    Ctrl-C
```

The key-command-driven user interface of Sea Of Fantasy BBS is typical of ANSI bulletin board systems.

log in and download shareware versions of the games. At its peak, the Apogee BBS (called Software Creations BBS) had 150 phone lines. Because of the shareware model, the trial versions of this software could be passed around to other BBSes around the world as well. If the player liked what they saw, they could pay (by cheque or electronically) and unlock the full versions. Yes, this was Steam, 1991-style.

Downloads weren't limited to software. Text files were a common type of file that could be downloaded. There were BBSes focused on subjects such as UFOs or hacking and phreaking, with reams of fascinating information that wouldn't be available through mainstream publications. Linux distributions could also be downloaded. Downloading a 25-disk Slackware disk set might take an entire week of late-night BBS calls, but it could well be the easiest way of getting Linux installed on your computer, particularly if you didn't have a CD-ROM drive.

QUICK TIP

UK BBS users were charged by the minute to use the phone. Kingston upon Hull in Yorkshire was a curious exception and had a massive BBS scene.

FidoNet

Before long, the earliest BBSes offered some form of electronic mail. Initially, you would be able to leave messages for the sysop and other users of that BBS. If you consider it, even that was quite a leap forward for electronic communication by the standards of 40 years ago.

The next step would be for these systems to incorporate forum-type features, a forum being a system that can involve more people at once and enable discussions. Typically, the forums would be divided into subjects. Each piece of BBS software could offer its own forum system. Many of these made use of the fact that the single-tasking operating system MS-DOS could launch a child program and then return to the parent program that launched it. Many BBS systems relied on this functionality to offer services such as online games.

APOGEE SOFTWARE PRODUCTIONS
DUKE NUKUM
PRESS F1 FOR HELP
EPISODE ONE: "SHRAPNEL CITY"

Games like the Duke Nukem series of games embraced the shareware software model and BBS distribution.

One of the most popular standards for BBS forum facilities was called FidoNet. This offered threaded discussions within subforums (called echos).

You could read your messages from within the BBS's text-mode interface, but FidoNet offered two massive advancements over earlier systems. Firstly, you could download messages from the system and add them into your own messagebase using FidoNet software, meaning that you could scour through the message forums while offline, compose new messages and reconnect to send your messages.

The second advance of FidoNet was the biggie. The different FidoNet BBS systems were linked in a network. BBSes in each region would ring each other up and exchange messages. Using this method, forum messages were propagated around the BBSes of the local region, entire countries and between continents. In practice, your forum post might take a few days to reach another country, but it was an amazing feeling for users getting their first taste of routine international communication. As well as being a taste of what was to come, it was a viable proposition for any owner of a home computer and a modem by the mid-'80s.

The rise of the internet

The early days of computer networks, such as the internet, dial-up ANSI BBSes and others, contributed to online culture that still exists today. Hacker speak (or l337 speak) is an example of something that developed on the BBS scene.

Much of the online slang and terminology that we take for granted now originated within these early online environments. Spam messages, being pwned, experiencing lag, dealing with noobs, having a handle, flame wars, lurking, being told to RTFM – all of these terms emerged from this era. As well as being a stylised way of engaging in conversation, elite was a status level that existed on some BBSes, allowing some users to access restricted areas of the BBS.

When internet usage began to explode in the middle of the '90s, BBS usage experienced a steep decline. In fact, the majority of the population didn't even know that there had been earlier online communication networks before the existence of the internet. In countries like the UK, early internet access, via services such as CompuServe and AOL, was still expensive and required quite a powerful computer, so the BBS scene limped on for a while. Some BBSes were even able to offer access to internet resources. For example, some BBSes offered an email address accessible via the BBS interface. Others even offered a text-mode web interface via a gateway.

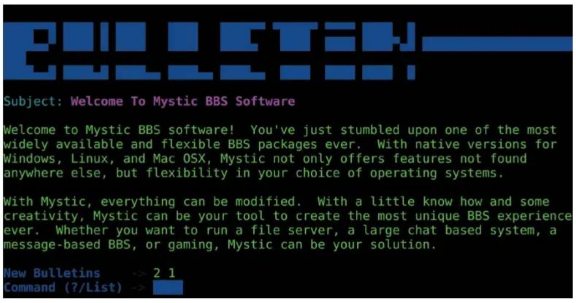
Bit by bit, an internet account seemed to be more useful than visiting BBSes, and the majority of the old systems had closed down by the start of the 2000s.

BBSing today

Compared to its peak in the mid-'90s, the BBS scene has largely disappeared due to people switching over to the internet. There are still some BBSes in operation today, though, and they are easy to visit on modern hardware through the use of internet protocols. Telnet is a protocol designed for text-mode connections between computers over TCP/IP. A terminal application that supports Telnet can give an experience comparable to connecting to a BBS over a modem, except that the connection is lightning fast. For comparison, an early '90s 14.4k modem would take about four or five seconds to load an entire page of information.

There are various lists of active ANSI BBSes available online, such as the Telnet BBS Guide (**www.telnetbbsguide.com**). Just like a website, the address of a Telnet BBS is given as either a URL or an IP address, rather than a phone number.

Electerm (**https://github.com/electerm/electerm**) is a modern, open source terminal application that supports connection to ANSI BBSes over Telnet, among other protocols and standards. It's present in the repository of most distributions. Importantly, it supports bookmarking, which is similar to the phone book of terminal applications of the dial-up age. If you want to host a BBS on the internet, *Synchronet* (**www.synchro.net**) and *Mystic BBS* (**www.mysticbbs.com**) are fully-featured open source software that have a Linux version.



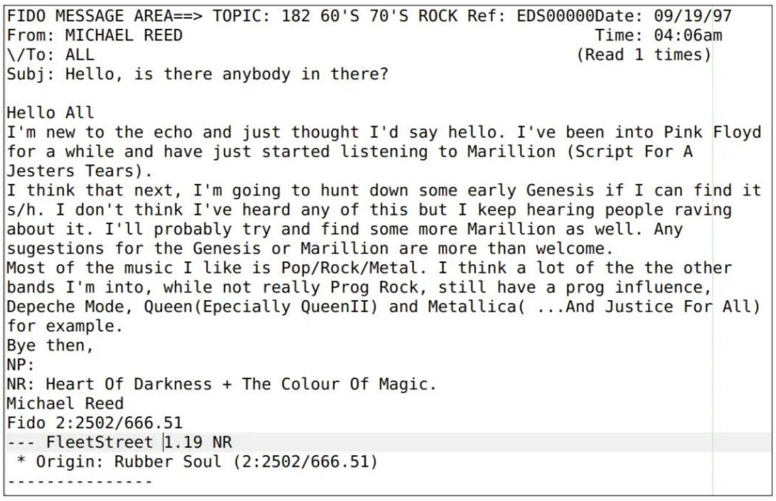
```
Subject: Welcome To Mystic BBS Software

Welcome to Mystic BBS software!  You've just stumbled upon one of the most
widely available and flexible BBS packages ever.  With native versions for
Windows, Linux, and Mac OSX, Mystic not only offers features not found
anywhere else, but flexibility in your choice of operating systems.

With Mystic, everything can be modified.  With a little know how and some
creativity, Mystic can be your tool to create the most unique BBS experience
ever.  Whether you want to run a file server, a large chat based system, a
message-based BBS, or gaming, Mystic can be your solution.

New Bulletins    -> 2 1
Command (?/List) ->
```

Mystic BBS is BBS software that supports Linux, if you want to create your own bulletin board system.



```
FIDO MESSAGE AREA==> TOPIC: 182 60'S 70'S ROCK Ref: EDS00000Date: 09/19/97
From: MICHAEL REED                                          Time: 04:06am
\/To: ALL                                                 (Read 1 times)
Subj: Hello, is there anybody in there?

Hello All
I'm new to the echo and just thought I'd say hello. I've been into Pink Floyd
for a while and have just started listening to Marillion (Script For A
Jesters Tears).
I think that next, I'm going to hunt down some early Genesis if I can find it
s/h. I don't think I've heard any of this but I keep hearing people raving
about it. I'll probably try and find some more Marillion as well. Any
sugestions for the Genesis or Marillion are more than welcome.
Most of the music I like is Pop/Rock/Metal. I think a lot of the the other
bands I'm into, while not really Prog Rock, still have a prog influence,
Depeche Mode, Queen(Epecially QueenII) and Metallica( ...And Justice For All)
for example.
Bye then,
NP:
NR: Heart Of Darkness + The Colour Of Magic.
Michael Reed
Fido 2:2502/666.51
--- FleetStreet 1.19 NR
 * Origin: Rubber Soul (2:2502/666.51)
---------------
```

An early post made by the author on 19th September 1997 found in an online archive.

What you can expect to find when you connect to a modern ANSI BBS is similar to the dial-up BBSes of old. As in the classic era, most of the BBSes that are around now are themed around the region where that BBS is based or a specific hobbyist interest. Many of these are connected to FidoNet, which is also still going, although it isn't anywhere near as popular as it was. In fact, it's quite a surreal experience to be reading about a subject such as COVID-19 or the recent US presidential election on a text-mode interface.

So, if you ever manage to time travel back to 1985, remember that there's some online fun to be had if you can get to a home computer and a modem. **LXF**

QUICK TIP

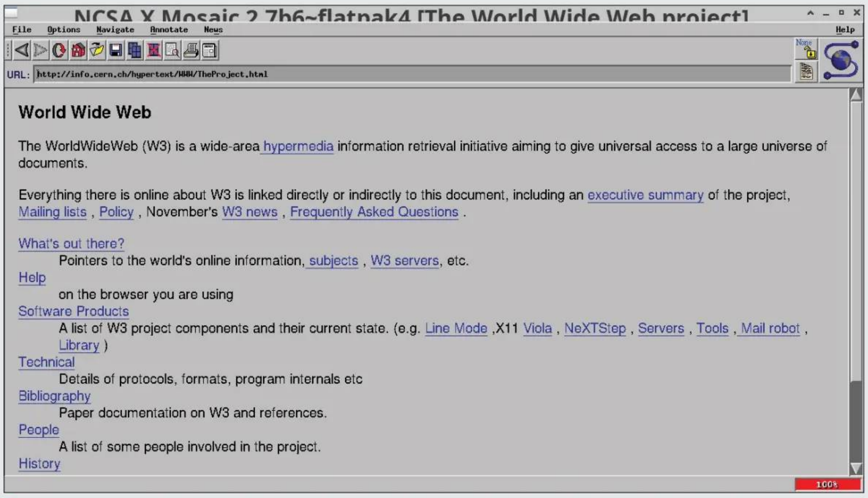
In about 1985, a 2400 baud modem was a good setup, and by the end of the BBS era (late '90s) most people had a 56000 baud modem, about 20 times faster.

» MEANWHILE, ON THE INTERNET...

While the BBS scene was establishing itself, parallel developments were being made on the burgeoning internet. It's difficult to say when the internet actually started because it was formed from a collection of earlier academic and military networks. Broadly speaking, the main network protocol used to transmit information over the internet, TCP/IP, was invented in the '70s and became more widely used over the course of the '80s, and the first World Wide Web server was invented by Tim Berners Lee in 1989 and made open source in 1993. Internet usage exploded from about the mid-'90s onwards.

On the internet, the Usenet system offered similar discussion facilities to those of FidoNet. Email was an early standard protocol and similar to FidoNet's netmail. FTP is a standard for uploading and downloading files. A later protocol, the World Wide Web, is the feature that generated massive adoption of the internet by the general public.

In the early internet days, BBS access had advantages for the home user. It favoured making sporadic connections without a dedicated connection to the server. Nearly every home computer could be persuaded to connect to a BBS, whereas, accessing the web required something a bit more powerful.



NCSA X Mosaic 2.7b6~flatpak4 [The World Wide Web project]
File
Options
Navigate
Annotate
News
Help
URL: http://info.cern.ch/hypertext/WWW/TheProject.html
None
100%

World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

What's out there?
Pointers to the world's online information, subjects , W3 servers, etc.
Help
on the browser you are using
Software Products
A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)
Technical
Details of protocols, formats, program internals etc
Bibliography
Paper documentation on W3 and references.
People
A list of some people involved in the project.
History

Mosaic, the first mainstream web browser, the killer app that popularised the internet.

BACK ISSUES » MISSED ONE?

ISSUE 328
June 2025

Product code:
LXFDB0328

LINUX FORMAT
UBUNTU BLASTS OFF
100

In the magazine
Ubuntu 25.04 blasts off, and we explain how to install it alongside Windows. You can also learn how to encrypt files via the terminal, write music scores, create custom health-monitoring graphs, and more. Plus, discover which secure browser best suits your needs, try your hand at a Pi project, explore our hacking and coding sections, and read about all the latest open source happenings.

ISSUE 327
May 2025

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LXFDB0327

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MAKE LINUX MOBILE
100

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Make Linux mobile by installing it on your phone. Plus, discover how you can draw in the terminal, secure your backups in the cloud, monitor your health the open source way, and choose the perfect 3D printer. Also, read all about the best Ubuntu alternatives, dive into our brand-new hacking section, learn about Nvidia's new GPUs, and catch up on the latest Linux and Pi news.

ISSUE 326
April 2025

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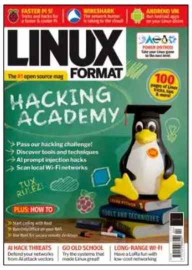
LXFDB0326



In the magazine
Join our Hacking Academy and discover all the tools and techniques to get started. Plus, find out which power distro is the best, read our interview with the *Wireshark* founders, defend your network against AI threats, run Android apps on Linux, and learn about the hardware that made Linux great. You'll also find our usual news and reviews, along with a packed Pi section and more.

ISSUE 325
March 2025

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LXFDB0325

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FIREWALL YOUR HOME
100

In the magazine
Protect your network with our in-depth guide to firewalling your home, and take a deep dive into Intel's new Arc series of GPUs. You can also discover how to up your password security, contribute to OpenStreetMap, stream audio with Auracast, relive the world of data punch cards, and upgrade your router. Plus, discover the best screen recorder, catch up with open source news, and more.

ISSUE 324
February 2025

Product code:
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GET INSIDE OPEN AI!
100

In the magazine
Get inside open AI and discover how to train your own chatbot, as well as find out which existing free chatbot we think is the best in our *Roundup*. Plus, take a step back in time with our look at plotters, build your own Steam Deck alternative, explore the new Pi 500, code your own *Space Invaders* game, take a look at the latest distro releases, catch up on open source news, and loads more.

ISSUE 323
January 2025

Product code:
LXFDB0323

LINUX FORMAT
ESSENTIAL Pi BUILDS
100

In the magazine
Follow our pick of Raspberry Pi projects and kick-start your maker hobby. Plus, learn all about *Fyne,* the toolkit that makes it easy to build cross-platform apps. We also take a look at five of the best IDEs, and some of the latest distro releases. And you can get stuck in with tutorials on rescuing deleted files, backing up web pages, getting involved with OpenStreetMap, and much more.

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LINUX HARDWARE

The hardware that made Linux great

Part four! Missed an issue? Back issues page 64!

To bring our series to a close, **Mike Bedford** looks at what might be Linux's greatest success stories: the behemoths of the computing world.

OUR EXPERT

Mike Bedford hasn't had the chance to use a supercomputer. If anything, though, since familiarity supposedly breeds contempt, this has done nothing to diminish the wow factor he feels when delving into the world's latest and greatest.

This article brings our series of articles on *The Hardware That Made Linux Great* to a close, but it's going out with a bang. Our subject this month encompasses several processor families, including the x86 that gave birth to Linux, but the common denominator is their application in high-performance computing. In referring to HPC, as it tends to be called among those in the know, we're talking about supercomputers, so we're going to be looking at the absolute top echelon of computing. In other words, we're going to be delving into computers that are upwards of a million times faster than the PC sitting on your desk. What's more, this is one class of computer where Linux can be considered as nothing less than essential. And our justification for saying that? Well, each and every one of the world's top 500 computers boasts our favourite operating system. In fact, none of the 500 fastest computers have used any other operating system for the last seven years.

Introducing supercomputers

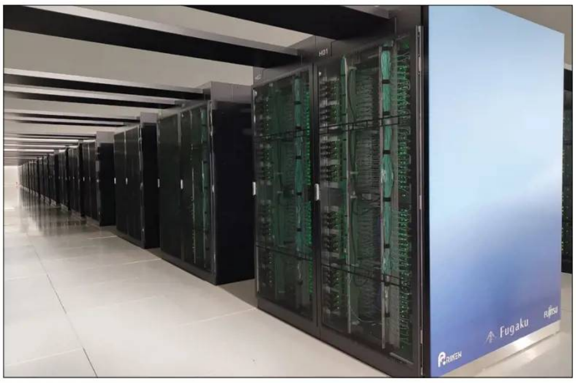
In the world of supercomputing, a machine's place at the top table is assured by its inclusion in the Top 500 list. Published in June and November each year, the list at **http://top500.org** shows the world's fastest computers in order of their performance. Specifically, the ranking is dependent on performance as measured by floating point operations per second – FLOPS or flop/s. As this is being written, the current list, which appeared last November, is the 64th, the first having been published in June 1993. As you can no doubt imagine, those 32 years have shown massive performance gains. The first ever Top 500 list was headed by a CM-5 supercomputer made by Thinking Machines Corporation and installed at the Los Alamos National Laboratory in America. It used 1,024 processors and clocked up 59.7 gigaFLOPS. We'll take a better look at it soon, but the machine at the number one position in the most recent list boasts a maximum speed of 1.742 exaFLOPS. Computer users are familiar with large numbers, but if you're hazy about the really large ones, an exaFLOPS is a thousand petaFLOPS, a petaFLOPS is a thousand teraFLOPS, and a teraFLOPS is a thousand gigaFLOPS. The upshot of this is that the world's current fastest computer is almost 30 million times faster than 1993's greatest. We could describe that growth as Moore's Law-ish, in that the true law referred to the number of transistors on a chip. Like Moore's Law, though, it's exponential, which means that numbers double over each equal time interval. The doubling time for supercomputer performance has been about 14 months over the 32 years of the Top 500 list – interestingly, that's faster growth than we have seen in the performance of processor chips. Here, the period appears to have been, very approximately, every two years over the same 32 years, fuelled initially by increasing clock speeds and more recently by increasing the numbers of cores.

So, what of that 1.742 exaFLOPS computer that heads the Top 500 list? The machine in question is

Lawrence Livermore National Laboratory
ENERGY
NNSA
Hewlett Packard Enterprise
AMD
Red Hat
EL CAPITAN
ADVANCED SIMULATION & COMPUTING

It might be a challenging climb in Yosemite National Park, but among the supercomputer community, creating El Capitan represented a very different challenge.

CREDIT: Garry McLeod/LLNL



Alongside the dominant x86 ISA, ARM chips also get a look-in for powering supercomputers. The ARM-based Japanese Fugaku held the top spot in the Top 500 list for 18 months

called El Capitan, and it's housed at the Lawrence Livermore National Laboratory in California. To add to that performance figure, we can tell you that all that computing muscle is courtesy of two different types of processor. First there are 1.8GHz AMD 4th Gen EPYC 24-core processors, 43,808 of them, providing 1,051,392 CPU cores. And there are 43,808 AMD Instinct MI300A GPUs, which provide 9,988,224 GPU cores. So, we're talking of a computer with over 11 million cores, CPU and GPU cores combined. Turning to memory, the capacity is over five petabytes and, while information on storage capacity isn't currently available, the system at second place in the Top 500 list, the 1,353 exaFLOP Frontier, has 37 petabytes of local storage, and access to 317 petabytes on site-wide storage. El Capitan consumes 35MW of power – which is just a bit less than the power consumption of Boston in Lincolnshire, a town of 45,000 – it's housed in 87 cabinets, and it occupies a floor area equivalent to two tennis courts. Oh, and it cost $600 million.

It's interesting to note that, in using AMD EPYC chips, El Capitan is built around x86 architecture chips, which date back to 1978. It's also the ISA which, in the form of the Intel 80386, was the hardware on which Linux first ran in 1991. Needless to say, today's x86 chips bear little resemblance to x86 chips of 34 years ago, even if they do share a common heritage and have some instructions in common. To cut a long story very short, due to a range of additions to the instruction set, the migration to multi-core chips, and architectural advances that are invisible to the user, top-end x86 processors are now immeasurably faster than the 8088 that powered the very first IBM PC. The x86 ISA isn't unchallenged in the world of supercomputers, though, as you can read in the box *(above)* where we look at the processors in the Top 500 list.

El Capitan wasn't the first exascale computer. That was the Frontier supercomputer at the Oak Ridge National Laboratory in Tennessee.

CREDIT: www.flickr.com/photos/mah_japan/53764346124/Masahiko Ohkubo.
/OLCF at ORNL https://commons.wikimedia.org/wiki/File:Frontier_Supercomputer_(2).jpg

» PROCESSORS IN THE TOP 500 LIST

Unlike our previous articles in this series, we've said very little in the main text about processor types. You might have noticed that the El Capitan supercomputer uses AMD 4th Gen EPYC CPUs and that, of course, adheres to the x86 ISA. And it's by no means alone in that respect, with the majority of the machines in the Top 500 list using x86 chips. There are other processor families represented, though.

Next up are those machines based on ARM architecture – in the guise of the Fujitsu A64FX and the Nvidia Grace – one of which hit the top spot in the list in 2020 and was still there as recently as November 2021. Indeed, this ISA appeared to be the up-and-coming ISA in HPC only a few years ago. However, while that might still happen, and numbers are increasing, only 18 machines in the current list boast an ARM-based chip.

In addition to these ISAs, we find four systems that use IBM Power processors. This, you might recall, was one of the RISC chips of the '80s and '90s that we looked at two months ago, and the only one to still be under development. But while it was once a major player in the Top 500 list, it's now very much in decline from its peak of over 40% of the world's fastest computers in 2020. About the only other ISA we could find was the Chinese Sunway chip, which features in just one supercomputer, the former top spot Sunway TaihuLight.

Supercomputer applications

We're going to look at the benefits of Linux in HPC, and at why the OS now dominates supercomputing and could almost be thought of as the only sensible option, but first, we're going to investigate some of the applications of supercomputers. After all, it might seem almost unbelievable that there are computing workloads that give a supercomputer a good workout, when such a machine can execute over a quintillion floating point operations per second. And it might seem equally unimaginable that such applications can be sufficiently parallel to make good use of many millions of CPU and GPU cores.

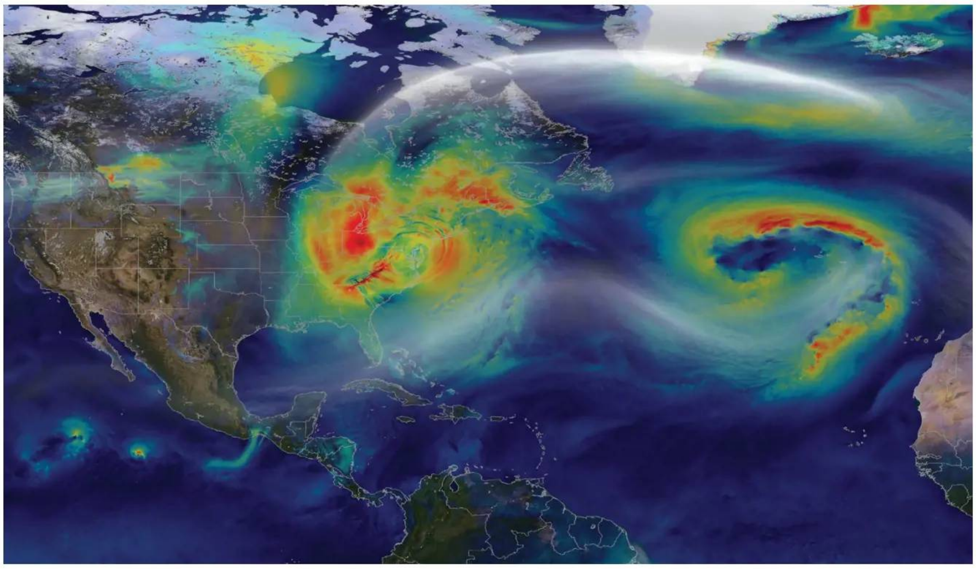
We'll look at the second of those points first – what type of applications have adequate parallelism to employ all those cores? Eight miles from Harrogate in North Yorkshire stands RAF Menwith Hill. Recognised by its 37 giant golf balls, actually satellite dishes inside their protective housings, it's been described as the largest intelligence-gathering, interception and surveillance base outside the USA. Needless to say, details are in short supply, but it's believed that one of its main purposes is to monitor phone calls and textual messages on a continual basis. And it's thought that its capacity could be measured in hundreds of millions of data streams per day. Since those messages are basically independent, it's not hard to imagine how such a surveillance regime can make good use of massively parallel computers. And this is just one example of a range of supercomputer applications that come within the broad classification of data mining.

But supercomputers can also be set to work on applications that don't seem to operate on such largely independent data streams and might, therefore, appear to be much less suited to massively parallel

»

QUICK TIP

We referred to Roadrunner being the first practical Linux supercomputer to make it into the Top 500 list in 2008, but it wasn't the absolute first. The first ever Linux-based machine to feature in that illustrious list was Avalon in 1998. It was actually constructed from 68 PCs, each running DEC Alpha processors, and it cost just $150,000 to build.



Like so many supercomputing applications, weather forecasting is able to make good use of the massively parallel architecture of today's fastest computers.

computer architectures. This takes us to solving sets of differential equations, a key technique in simulation, which is another very important and common application area for supercomputers.

The data stream here is usually a set of initial conditions – the values of all the variables at the start of the simulation. The computation involves solving the various equations to obtain the values of those variables repeatedly over the time period of interest. The reference to solving the equations repeatedly doesn't sound like an inherently parallel process, and it's not. However, many of the most computationally intensive simulations involve solving those equations for many points in either a two- or three-dimensional grid. A 2D grid, for example, could represent positions on the surface of a Formula One car during a CFD (computational fluid dynamics) exercise for aerodynamic design. And turning our attention to three dimensions, we could be looking at positions in the atmosphere at different geographical locations and at different altitudes, as required for weather forecasting.

Accuracy of the simulation is improved by using a sufficiently small time step but it is also improved by using sufficiently small grid cells. As such, the number of cells often runs into the millions. But, crucially, the same equations are solved in each of those cells, and the requirement to share data between cells is limited. Basically, the computation in each cell requires the values of each variable in the cell being worked on, plus those of its immediate neighbours. It's easy to imagine how this sort of workload can, indeed, take advantage of the huge numbers of CPU and GPU cores available on supercomputers.

So, we've seen a couple of examples of broad application areas that are well suited to the massively parallel approach that virtually all supercomputers employ. But what about specific applications? The primary application of El Capitan, according to the Lawrence Livermore National Laboratory where it's based, is "to help researchers ensure the safety, security and reliability of the nation's nuclear stockpile in the absence of underground testing". In addition, they say, "El Capitan also supports unclassified mission areas of interest to national security, including material discovery, high-energy-density physics, nuclear data, material equations of state, and conventional weapon design." The Top 500 list shows a terse application area for each machine it lists, but since 98.8% of the machines have this shown as "other", this isn't very useful. However, perusing the application area as stated by the organisations that host the top 25 systems, we discover that, while the stated application area for several of the world's fastest computers is defence-related, the wide array of non-military applications provides some interesting insights. And here's the list, abbreviated and partial, as it most certainly is: AI, machine learning, drug development, climate science, high-efficiency jet engine design, nuclear fusion research, astronomy, green energy transition, particle physics, materials science, earth sciences, quantum computing, cryptology, semiconductor design and weather forecasting.

It's also interesting that no application area is suggested for several of the top 25 machines in the Top 500 list. This is because the machines in question were not built or bought by organisations with specific computing requirements. Instead, these machines were installed to provide a commercial HPC service in the cloud. Take, for example, Microsoft Azure Eagle, which made its debut in the Top 500 list at position three in 2023, and currently occupies the number four spot. It's targeted at users who need to train extremely large artificial intelligence models. To do that, it boasts 2,073,600 cores, up from its original 1,123,200, and clocks up 56 petaFLOPS. And not only does it provide a service in the cloud, but the hardware that provides that service is also distributed throughout the cloud. We can't imagine the eye-watering fee you'd pay to get in on the action as a user of Eagle.

The Linux advantage

In 2008, a supercomputer called Roadrunner hit the top spot in the Top 500 list and became the first computer to hit the petaFLOP milestone. It also marked another first. Although an experimental supercomputer had previously run Linux, this machine

QUICK TIP

From its current lowly 62nd position in the Top 500 list, the UK is expected to return to a top-10 spot in the near future, thanks to the Isambard-AI machine, which has recently gone live. Currently it's at position 129, but it should be fully up to speed in the summer.

GW4
UK Research and Innovation
NVIDIA
arm
Hewlett Packard Enterprise

Named after the 19th-century engineer Isambard Kingdom Brunel, the Nvidia Grace-powered Isambard-AI is expected to become the UK's top placed Top 500 machine with a top-ten spot.

CREDIT: https://www.flickr.com/photos/gsfc/8971451260/in/photostream//NASA Goddard Space Flight Center.
https://nvidianews.nvidia.com/multimedia

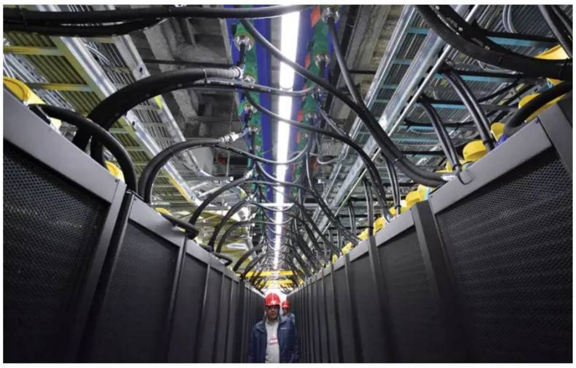
is commonly considered the first practical Linux supercomputer. What a difference a day makes – or, in this case, 17 years – as now there are 499 more Linux supercomputers in the Top 500 list than there were in 2008. Let's investigate why.

Whatever you might think about the benefits of Linux compared to other operating systems, we have to admit that the choice of which OS to use is, to a degree, driven by personal preferences. After all, if that wasn't the case, it seems implausible that four main operating systems would be available for desktop and laptop computers, and all have their staunch supporters. This being the case, it's pertinent to ask why there is no such diversity in the world of high-performance computing. In other words, why is Linux used on every single one of the world's fastest 500 supercomputers? It'll probably come as no surprise that the answers refer to the benefits of Linux that you might cite, namely free and open source.

We all know that Linux is free but, you might wonder, would the cost of a licence for a commercial operating system really make much difference in the grand scheme of things when you're spending hundreds of millions on the hardware. After all, the cost of Windows 11 would only add about 0.00003% to the cost of El Capitan, today's fastest computer. Certainly, that would be negligible, but we're not comparing like with like. If we stick with Windows – and supercomputers have indeed used Windows in the past – we wouldn't be talking about everyday versions like Windows 11. Instead, an operating system designed for large systems would be used, and these are licensed differently. Take, for example, Windows Server 2025 Datacenter Edition. The licence cost depends on the number of cores, with the minimum of 16 cores costing $6,771, and additional licences being required for additional cores. Taking that at face value, the cost of a licence for El Capitan would exceed that of the hardware by a significant margin. However, we can imagine that discounts might apply if you're licensing huge numbers of cores, and it's not clear if GPU cores are charged in the same way as CPU cores. Nevertheless, there's one thing we can be sure of: it's not exactly going to be cheap to buy a commercial operating system licence when you have a machine with millions of cores. On the other hand, free is still free with Linux, irrespective of how many millions of times you multiply up its zero licence fee.

Next we come to the open source nature of Linux, and why this is of particular relevance to supercomputers. After all, while this is a major plus point for many computer enthusiasts, we have to assume, based on the prevalence of other operating systems, that this isn't universally accepted among many commercial users. So, what makes supercomputers so different? Needless to say, we're talking about the benefit that open source provides in allowing customisation of the operating system, but why is this especially relevant to the HPC market? One example, which was provided to us by an expert in supercomputing at a British university, is that optimisations might be needed to improve jitter by removing utilities that occasionally start up, but which aren't really needed in a supercomputing environment. These might be daemons that check on printers and other peripherals, which are important on desktop systems but not in a supercomputer. Other areas that are commonly optimised include communication between machines, and for data transfer with large, parallel filesystems. Our spokesperson also stressed the open source benefit of allowing supercomputers to integrate a wide variety of different devices – including storage systems, networks, different processors and GPUs – and so the ability to rapidly add new high-performance device drivers is a major advantage.

In a couple of our previous articles in this series, we concluded by saying that, while Linux didn't exactly make the various computing platforms great, those platforms did make Linux great. There are two aspects to that statement. First, in both the RISC workstations and servers of the '80s and '90s, and the second generation of home computers, Linux appeared too late to make a huge difference. Conversely, though, in providing additional processor families and platforms on which to port Linux – many of them quite different from the 80386-based PC on which it first appeared – it proved that Linux truly had what it takes to become a great operating system. This subject is surely an ideal place at which to bring this series to a close in being an example of hardware that was made great by Linux, and also of hardware that made Linux great. LXF



This cooling system on a US DOE machine hints at the huge energy consumption of supercomputers. It's no surprise, therefore, that energy efficiency is becoming increasingly important.

CREDIT: U.S. Department of Energy, www.rawpixel.com/image/8733424/photo-image-public-domain-computer

» THE GREEN 500 LIST

In June 2013, in recognition of the fact that supercomputers are phenomenally power hungry, the Top 500 list was joined by the Green 500 list. In this list, systems that are also in the Top 500 list aren't listed in order of their processing power but in order of their power efficiency, expressed as FLOPS per unit of electrical power. And the advances made in the 12 years of this list are impressive.

In June 2013, the top spot in the Green 500 list was occupied by the Eurotech Aurora HPC 10-20, which achieved 3.208 GigaFLOPS per watt, even though it had only scraped into the Top 500 list at position 468. In the most recent list, the efficiency of the number one computer – now held by JEDI BullSequana XH3000 – has increased to 72.773 GigaFLOPS per watt. Not only that, but energy efficiency no longer appears to be the sole domain of those computers lurking near the bottom of the Top 500 list. While today's greenest supercomputer is only 222nd in the Top 500 list, it's interesting to see El Capitan, the top-placed machine in the Top 500 list, coming in at a respectable 18th place in the list of the most environmentally friendly supercomputers.

QUICK TIP

Some of the world's fastest supercomputers use commercial versions of Linux, often Red Hat Enterprise Linux, and this somewhat diminishes the potential benefits of a free operating system. But this is by no means universal. The system currently at the number four spot, for example, uses none other than the Ubuntu 22.04 that many of us use on our own PCs.

DEBIAN

Credit: www.debian.org

Build the ultimate home server setup

Nick Peers reveals how to set up the ultimate in flexibility: your very own self-hosted system running all your services powered by Linux.

OUR EXPERT

Nick Peers signs off with a real labour of love. This project is based on five years' personal experience running his own self-built servers. Current *Podman* container count: 16 (and rising).

Dare we suggest that everyone needs their own home server? In these febrile times when privacy is under threat and the rentier economy keeps finding excuses to ramp up the cost of online subscriptions, taking back control of your data and services is a no-brainer. And what better way to do so than set up your own basic home server?

There's a free open-source equivalent for just about any online service you can think of, and you don't need fancy hardware to get started – you can press an old PC or laptop into service if you wish. However, servers are designed to be run 24-7, so unless you want to run up a huge electricity bill, you might want to explore a dedicated low-power option, such as a Raspberry Pi 5 or mini PC based around Intel's powerful – but energy efficient – 12th generation Alder Lake N100 chip. One such example is Beelink's MINI-S12 Pro range – aim for 16GB of RAM and a 500GB SSD, which would cost you around £220. If you have large amounts of data to store, hanging multiple USB drives off this might not be practical, in which case, check out the box *(below)* for a fully specced N100-based self-build with plenty of room for internal storage.

Off with its head!

You'll be running this server headless, which means that once it's up and running, you won't need a monitor, keyboard or mouse to access it on a day-to-day basis. Instead, you'll log on remotely through any browser to administer all aspects of your server using the *Cockpit* web-based front-end (**https://cockpit-project.org**).

But first, we need to install our underlying operating system, and we've chosen the latest stable release of Debian (12.10 at time of writing) for the job. Head to **www.debian.org** and click Download to save **netinst.iso** (a mere 648MB) to your hard drive. You need to create USB bootable media from this – most distros provide a tool for writing ISO files to disk, such as *Startup Disk Creator* in Ubuntu or *USB Image Writer* in Mint.

Once created, insert the USB drive into a spare USB port on your server PC, which should also be temporarily connected to a keyboard, mouse and

» BUILD YOUR OWN SERVER

If you're looking to build your own NAS replacement – something to rival a QNAP or Synology drive – why not follow our own example? Here are the components we used (and how much they currently cost – from **www.scan.co.uk** unless stated) to build our own N100-based server.

Component	Model
Motherboard/CPU	Asus Prime N100I-D D4 (£100)
RAM	Crucial 16GB 3,200MHz DDR4 SO-DIMM (£29)
Case	Jonsbo N2 Mini-ITX NAS chassis (£140, **www.watercoolinguk.co.uk**)
PSU	BeQuiet! SFX Power 3 – 300W (£50)
Boot drive	WD Red SA500 SSD – 500GB (£57) or 1TB (£84)
SATA adaptor	ASM1166 M.2 M Key to 6-port SATA 3.0 adaptor card (£24, eBay)
2.5GB/s Ethernet port (optional)	StarTech ST1000SPEX2 (£26, **www.startech.com/en-gb**)
TOTAL OUTLAY	£400-£455 (minus additional storage)

PRIME N100I-D D4
/ISUS

The N100 chipset draws very little power, but its quad-core CPU can run over a dozen containers with ease.

monitor for the setup process. Boot from the drive, which should detect the Debian boot media and take you to its UEFI Installer menu. Leave Graphical Installer selected and press Enter. This works in a similar way to most distro installers, so work your way through it.

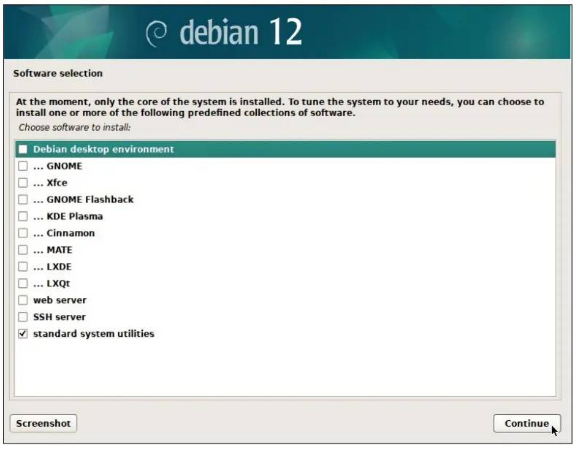
Home addresses

Certain parts of the process require careful consideration: the first is when Debian detects your network interfaces – if you have more than one network interface installed, you need to select which one to configure (preferably the wired one for a faster, more stable connection). It is automatically configured using DHCP – we'll switch it to a static IP address post-install. For now, give your server a suitably identifiable hostname (such as **server-pc** or **home-server**) to make it easy to identify from other network devices before continuing. Skip the domain name prompt.

When prompted for a root password, leave it blank – this sets up Debian like Ubuntu-based OSes, where your own user account is given administrative access via the *sudo* command. When partitioning the disk, leave Guided – Use Entire Disk selected; LVM isn't really needed for a server that will be administered by a single person. If you decide to create a separate **home** partition, which is where most of your data (including any *Podman* containers you set up) will be housed, the installer allocates 30GB to the **root** partition and gives the rest to your **home** partition.

After the drive has been partitioned, you're prompted to scan additional media for the package manager. Leave No selected and click Continue. You may also wish to switch package manager to **ftp.uk.debian.org** when given the opportunity. Another important choice comes up when asked to select and install software – the key thing here is to untick both Debian Desktop Environment and Gnome. You may want to tick SSH Server alongside Standard System Utilities, but it's not necessary, thanks to *Cockpit.*

Once the core packages are installed, you're ready to reboot – remove the installation media before doing so. Debian is now installed and it's time to move on.



Software selection

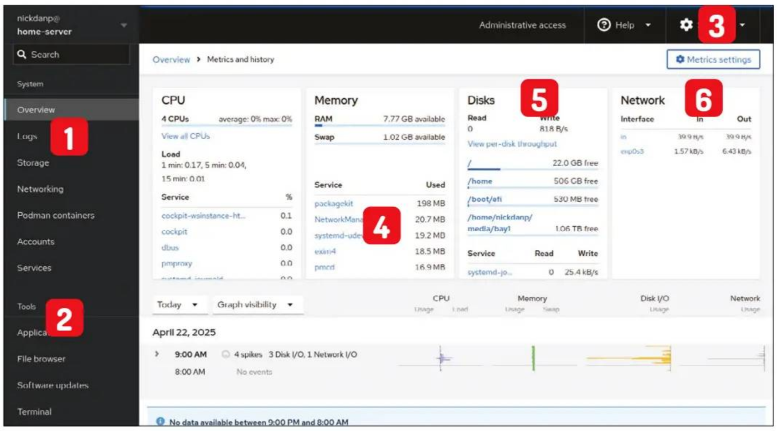
At the moment, only the core of the system is installed. To tune the system to your needs, you can choose to install one or more of the following predefined collections of software.

Choose software to install:

- ☐ Debian desktop environment
- ☐ ... GNOME
- ☐ ... Xfce
- ☐ ... GNOME Flashback
- ☐ ... KDE Plasma
- ☐ ... Cinnamon
- ☐ ... MATE
- ☐ ... LXDE
- ☐ ... LXQt
- ☐ web server
- ☐ SSH server
- ☑ standard system utilities

Debian's graphical installer makes getting up and running a breeze – just make sure you remove the desktop environment option as shown.

NAVIGATING COCKPIT



1 System tools
Switch between *Cockpit's* core tools here – each has its own page giving you access to different parts of the system.

2 Tools
This section covers a range of apps and services – the File Browser is an optional add-on *(see Quick Tip, p.74).*

3 Session controls
Click here to switch themes and display language, manage SSH keys and log out of the current session.

4 Services
Use the metrics to monitor services, then switch to the Services tab to manage them directly.

5 Disks
Get an overview of how full your disks are getting from here – click any drive to jump to the Storage section.

6 Network
Monitor all network interfaces – physical and virtual (such as *Podman* networks) from here.

First boot setup

Leave the computer connected to your keyboard and display for the next step. The GRUB menu appears, and after a few seconds, it boots to a standard text-based login prompt. Enter your username and password, and you'll end up at the following command line prompt:

```
username@pcname:~$
```

Because this is a basic Debian install, you'll be pleased to know that the knowledge you've acquired using the terminal on your PC is transferable here. Let's begin by creating a 4GB swap file to replace the rather parsimonious 1GB swap partition created during installation:

```
$ sudo fallocate -l 4G /swapfile
$ ls -lh /swapfile
```

The second command confirms the swap file is in place (owned by root) and ready to go. Now let's install our *Cockpit* front-end. The version in the stable default repository is outdated, so let's install the much more up-to-date build by enabling Debian's backports repo:

```
$ sudo -i
```

(After entering your password, you're dropped to the `root@pcname:~#` prompt.)

```
$ . /etc/os-release
$ echo "deb http://deb.debian.org/debian ${VERSION_CODENAME}-backports main" > \
  /etc/apt/sources.list.d/backports.list
$ exit
```

Once returned to the main dialog, enter the following (substitute `bookworm` with `trixie` if you're running Debian 13, due for release later this year):

```
$ sudo apt update && sudo apt install -t bookworm-backports cockpit
```

Test connection

Next, type `ip addr` to discover what IP address has been allocated to your server by your router. Now switch to your main PC and type the following into your browser's address bar (substitute `192.168.x.y` with your

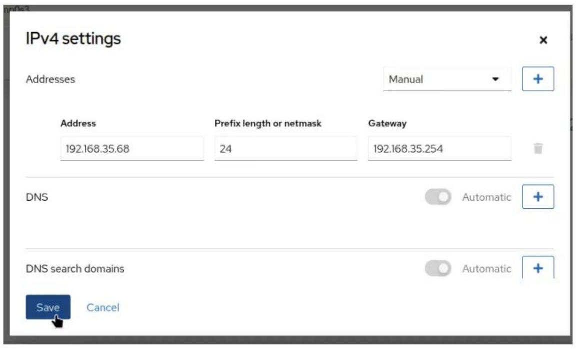
QUICK TIP

If you envisage serving multiple connections to your server, consider adding a second Ethernet port as outlined in the self-build box *(opposite)*. This won't double your network speeds, but it will double its throughput, so it can better handle those multiple connections. Visit http://nickpeers.com/podman for a guide to setting up two Ethernet interfaces in *Cockpit.*

»

QUICK TIP

One missing element from *Cockpit* is a file manager. There's a Files plugin available, but it's not currently available in Debian repos. Visit https://github.com/cockpit-project/cockpit-files/issues/635 for a discussion and current workaround involving manually installing a DEB file (adapt this to v16, not v14).


IPv4 settings

Addresses: Manual

Address	Prefix length or netmask	Gateway
192.168.35.68	24	192.168.35.254

DNS: Automatic

DNS search domains: Automatic

Once you've set Debian to use NetworkManager, you can configure your network with ease using Cockpit's Networking component.

server's IP address as listed on the inet line under your Ethernet adaptor's entry):

```
https://192.168.x.y:9090/
```

If *Cockpit* is running, your browser should flag up a potential security risk due to the lack of an SSL certificate. Wave this through – for example, *Firefox* users should click Advanced followed by Accept The Risk And Continue – and you end up at the *Cockpit* login screen. Log in with your server's username and password to find yourself at the main *Cockpit* web interface, ready to explore (and configure) your system.

Settle into Cockpit

The annotation *(p.73)* reveals how easy your new server will be to monitor and administer going forward, but you'll notice you're running in limited access mode. Click Turn On Administrative Access and re-enter your user password to gain full access to your system – you should now only see this message if cookies aren't saved or you access via another browser.

The Overview screen provides a handy summary of your system – it's here you're notified that updates are ready to be installed via the Software Updates section. There are also some handy summaries of your setup as well as a shortcut to reboot or shut down your server at any point. Under Usage is a link inviting you to view hardware metrics and history – clicking this provides more information about your CPU, memory and disk usage, as well as the current network connection, but below this is a message telling you PCP is missing for metrics history. Simply click the Install PCP Support button to add the required packages.

You can also install these via *Cockpit's* terminal emulator. Click Terminal in the left-hand pane, where you'll discover you have direct access to the command line from here. Make a note of its handy clipboard support (Ctrl+Insert to copy from the Terminal, Shift+Insert to paste into it) alongside the ability to change the font size and background colour. To install PCP support from here, issue the following command:

```
$ sudo apt update && sudo apt install pcp python3-pcp
```

Set static IP

You can expand *Cockpit's* capabilities further with several plugins, but first let's nail down your server's IP address by assigning it a static address. This can be done from *Cockpit's* Networking section. Here you'll find your current network adaptor and IP address is listed under Unmanaged Interfaces. This indicates *Cockpit* can't manage it because Debian doesn't use *NetworkManager* by default.

We can fix this with a quick bit of work in the terminal with the following command:

```
$ sudo nano /etc/NetworkManager/NetworkManager.conf
```

Look for the line marked `managed=false` under `[ifupdown]`. Change this to `managed=true`, then press Ctrl+X. Press Y followed by Enter. Next enter:

```
$ sudo nano /etc/network/interfaces
```

Comment out all the lines except `source /etc/network/interfaces.d/*`, then press Ctrl+X followed by Y and Enter again. Finally, reboot your server. If you can't log back into *Cockpit,* check that your router hasn't allocated it a different IP address by checking the terminal output on your server (you'll see *Cockpit* displays a message on startup explaining how to access it remotely).

When you log back into *Cockpit* and return to the Networking section, your network appears under Interfaces – click its name as marked in blue to access it status page, where you can click Edit next to IPv4 to assign it a manual IP address. Select Manual from the drop-down menu, input your chosen IP address, leave netmask set to 255.255.255.0 and change Gateway to the IP address of your router.

After clicking Save, *Cockpit* tests your connection – click Change The Settings when prompted. Now reboot your server again and the new IP address should be in place permanently going forward.

Configure storage

Another key part of your server is access to your storage. This is done from the Storage section, where any connected USB drives should appear alongside your primary drive and any additional hard drives you have installed. Preformatted drives like USB simply need mounting to a suitable folder on your filesystem –

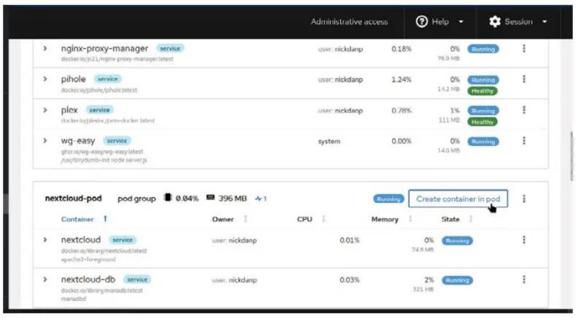
» YOUR FIRST CONTAINERS

It's impossible to compress into 200 words how to run a single container, never mind get you using your choice of containers. Instead, we've plundered Nick's old tutorials from sister magazine *Maximum PC,* coupled with his own up-to-date experience running a Debian-based server for the past 18 months, to provide you with a selection of guides to help you extend your server's capabilities.

Head over to **www.nickpeers.com/podman** where there's already a guide to setting up your own self-hosted password manager. By the time you read this, you may also find guides to a range of other containers, from *Jellyfin* (media streaming) and *Nextcloud* (self-hosted cloud sync and storage) to *Rustdesk* (completely free alternative to *Teamviewer)* and *Audiobookshelf* (audiobook server).

We'll also cover the thorny issue of how to access these services outside your local network. Whether you want completely private access through your own Wireguard VPN server or you'd like to extend access to friends and family through a user-friendly domain, there will be a tutorial for you to follow.

We've focused on providing instructions for getting the containers up and running, plus how to have them auto-start with your server – you can then explore the actual services via their websites. We've kept things simple, too – just copy and paste the edited scripts into your *Cockpit* terminal to run them. You'll see a deprecated warning when you set up the containers as services but this can be ignored.



Container	Owner	CPU	Memory	State
nginx-proxy-manager service	user: nickdanp	0.18%	0% 76.9 MB	Running
pihole service	user: nickdanp	1.24%	0% 14.2 MB	Running Healthy
plex service	user: nickdanp	0.78%	1% 111 MB	Running Healthy
wg-easy service	system	0.00%	0% 14.0 MB	Running

nextcloud-pod pod group 0.04% 396 MB 1 Running

Container	Owner	CPU	Memory	State
nextcloud service	user: nickdanp	0.01%	0% 74.8 MB	Running
nextcloud-db service	user: nickdanp	0.03%	2% 321 MB	Running

Thanks to Cockpit's Podman plugin, it's easy to view and manage your containers from your web browser.

we suggest opening the terminal, which defaults to your personal **home** folder, then issuing the following:

```
$ mkdir media
$ cd media
$ mkdir bay1 bay2 usb1 usb2
```

You can name these folders whatever you like – just make sure there's one for each drive attached to your server. Once created, you can set up your drives and mount them to these folders. To set up a hard drive from scratch (including wiping any existing data or partitions), check out the walkthrough *(below)*.

Install Podman

Once your system is set up, it's time to explore adding the services you plan to run from it. You can, of course, install these natively if suitable packages exist, but a better way is to run them all in sandboxed containers. They're easier to administer this way, plus none has the ability to bring your entire server crashing down.

There are several choices when running containers, the best known of which is *Docker*. However, we recommend its open source rival *Podman*, which is broadly compatible with *Docker* but has several advantages. First, there's no parent daemon process, so one container crashing can't affect the others. Second, *Podman* containers can be run rootless so they don't have access to potentially risky areas of your system. And finally, *Cockpit* offers a plugin so you can monitor your containers from its web-based interface.

You can install *Podman* from the main Debian repos, but the version is frozen at the point of that Debian release (in Debian 12, *Podman* is stuck at 4.3, which is woefully outdated). The safest way to install the latest version is through a dedicated repo. The commands are a bit convoluted, so visit **www.nickpeers.com/podman**, where you can copy (Ctrl+Insert) each command from the page, then switch to *Cockpit's* terminal and press Shift+Insert to paste them in one at a time. Once done, install the *Cockpit* plugin:

```
$ sudo apt install -t bookworm-backports cockpit-
podman
```

Press Ctrl+F5 in your browser to force a refresh, and you'll see a new entry marked Podman Containers. You can view, manage and even create containers from here, although we prefer setting them up directly from the command line *(see the box, opposite)*.

Beyond your first container

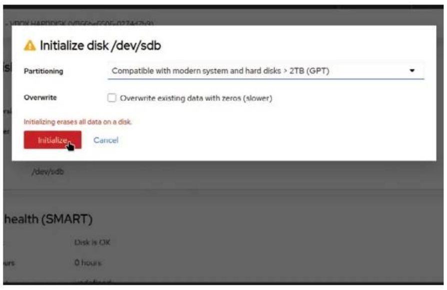
Podman works in a very similar way to *Docker*, but there are differences. Visit **https://docs.podman.io** for an introduction to what it is, how it differs from *Docker* and the core commands you can use. What you'll find when you go hunting for containers is that there's plenty of online information about running them in *Docker,* but not much about *Podman.* Try searching for the container's name and 'podman' to see if someone has documented their own successful experiences. In many cases, simply substituting 'podman' for 'docker' may work, but in others you may need to perform some major surgery to get containers designed for rootful *Docker* to work in rootless *Podman* (if all else fails, you can run that container as root by prefixing the *Podman* command with `sudo`).

For more help and advice on setting up containers – including suggestions of what to run – consult the boxout *(opposite)*; you're redirected to Nick's website, where he's putting up several quick tutorials on how to get specific containers running in *Podman.* **LXF**

QUICK TIP

If you're connecting to a previously formatted drive, click on the drive to open its properties, then click Mount to input the mount point such as /home/nickdanp/media/usb1. Once mounted, follow step 3 of the walkthrough to take ownership of the folder.

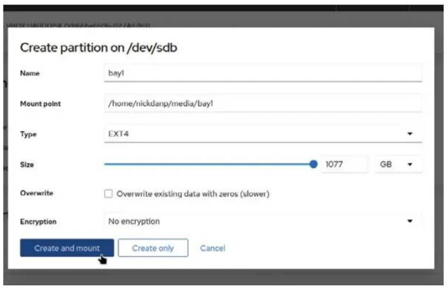
CONFIGURE A NEW HARD DRIVE



Initialize disk /dev/sdb
Partitioning: Compatible with modern system and hard disks > 2TB (GPT)
Overwrite: ☐ Overwrite existing data with zeros (slower)
Initializing erases all data on a disk.
Initialize Cancel

1 Set up new drive

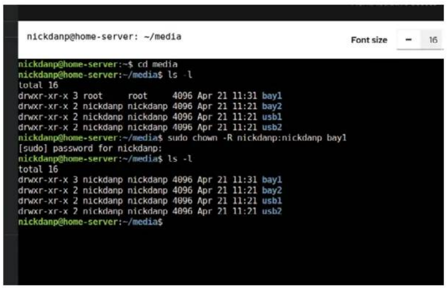
Open the Storage panel, where you'll see all connected disks and drives (**sda**, **sdb** and so on). Use the Type and Size fields to identify each. To set up a new drive from scratch, click its entry. Click the vertical ellipsis button next to Hard Disk Drive and choose Create Partition Table. Verify that GPT is selected as shown and click Initialize.



Create partition on /dev/sdb
Name: bay1
Mount point: /home/nickdanp/media/bay1
Type: EXT4
Size: 1077 GB
Overwrite: ☐ Overwrite existing data with zeros (slower)
Encryption: No encryption
Create and mount Create only Cancel

2 Mount the drive

Once done, scroll down to the GPT Partitions section. Click the vertical ellipsis next to it and choose Create Partition. Give it an identifiable name, then enter the path to the mount point on your system. Scroll down to check the other settings (if in doubt, the defaults can be left as they are). Finally, click Create And Mount. After a pause, the new partition should be listed.



```
nickdanp@home-server: ~/media
nickdanp@home-server:~$ cd media
nickdanp@home-server:~/media$ ls -l
total 16
drwxr-xr-x 3 root     root     4096 Apr 21 11:31 bay1
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 bay2
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 usb1
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 usb2
nickdanp@home-server:~/media$ sudo chown -R nickdanp:nickdanp bay1
[sudo] password for nickdanp:
nickdanp@home-server:~/media$ ls -l
total 16
drwxr-xr-x 3 nickdanp nickdanp 4096 Apr 21 11:31 bay1
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 bay2
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 usb1
drwxr-xr-x 2 nickdanp nickdanp 4096 Apr 21 11:21 usb2
nickdanp@home-server:~/media$
```

3 Claim ownership

Now switch to the terminal and type `cd media` followed by `ls -l` to view the mounted folder's properties. You'll notice that root has taken ownership of the newly mounted drive. To reclaim ownership of the drive, you need to adapt the following command to your own folder name and username:

```
$ sudo chown -R nickdanp:nickdanp bay1
```

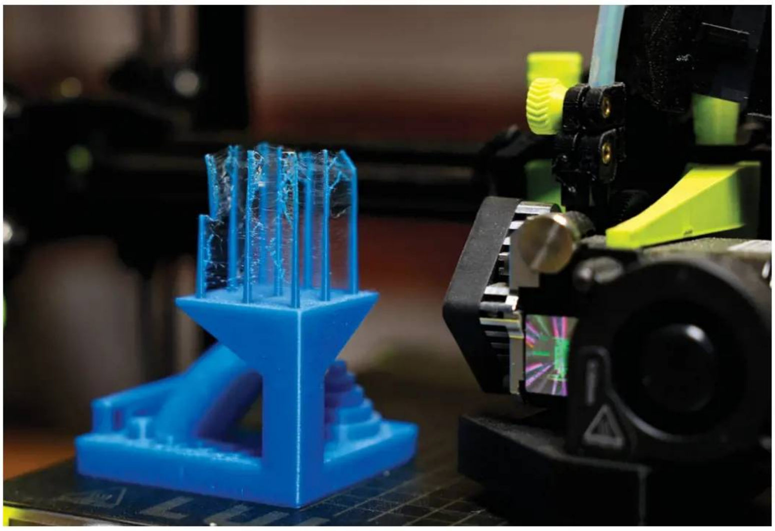
3D PRINTING

Your first month with a 3D printer

Some things aren't in the manual, which is why 3D-printing autodidact **Beth Nicholls** is here to share what she's learned!

OUR EXPERT

Beth Nicholls has a master's degree in photography, and worked as a tester for CeX, which let her play around with all kinds of weird and wonderful products, including robots. She's recently got into 3D printing.



The Autodesk benchmark is a way of testing how good your printer really is.

Having recently entered the world of 3D printing, this writer has found that the last few weeks have been a researching gold mine. After only three weeks since buying her first beginner 3D printer (after being tempted by a deal on TechRadar), it feels like we're getting to grips with how these machines work. However, there are a few things that we'd wish we'd known sooner!

So, we've put a few of our hard-earned top tips here, for anyone looking to buy a 3D printer some time this year. We do have a small confession, though. While we did initially consider an Anycubic, we changed our mind the next day and placed one from the Creality range plumping for the Ender-3 V3 SE instead. After scouring reviews, we felt that for the price this machine was a little better suited to the builds we wanted to make, with better Linux support, and decent printing speeds, too. It's a good lesson for those planning on buying a printer – it can be hard to narrow down exactly what you might need from it.

Anyhow, with that off our conscience, let's get into the things nobody really prepares you for when getting into 3D printing, and some hot tips we've learned during our first few weeks with our new 3D printer ideal for the beginner 3D printer.

1. Slicing and code

Not all 3D printers operate the same way, some models do not work well with STL (stereolithography) files – which we found out the hard way. Basically, when you're searching for an open source file to 3D-print from, using the likes of Thingiverse or Printables, these usually take the form of an STL file, which is a 3D model file and not often printable on its own.

When using a 3D printer, G-code is the standard language and preferred file type for most 3D printers, used to instruct the printer about precisely what you want it to do involving the extruder heat, nozzle and printing areas.

Thankfully, it's super-easy to convert STL model files into printable G-code format using what is known as a slicing process, or using slicer software. Our Ender-3 V3 SE came with *Creality Print* slicing software on the included microSD card, also known as Fused Deposition Modelling Slicer.

Once installed, this software enables you to see the 3D model in a three-dimensional format and make any changes you like by adding or removing supports (more on this later) and slicing up the print into manageable sections for your printer. You'll need to understand slicing if you intend to create your own designs and original 3D prints.

2. Supports

As we've just mentioned, more often than not you'll need to include supports in your 3D model and 3D prints for them to be solid and stable. You can't print on thin air, so supports are important to ensure that your design prints as it should if there are parts that overhang or extend past a 45-degree angle.

These support structures can take the shape of breakaway supports, tree-like supports, zig-zags or linear supports made of vertical pillars. You can also

You can also create your very own 3D-printed Pokémon!

get dissolvable supports made from water-soluble materials that disappear, but you'll need a printer with a double extruder to pull this off. Online website All3DP has an excellent guide to understanding print supports if you need more advice.

There is a downside to using supports, though, as we discovered with our latest large build, where they can be very difficult to remove, risking damage to your print and the potential to cause minor injury (yes, really – see the photo, *page 77*). We used tree supports with the latest 3D print, courtesy of Peter Farell via Printables, and found out the hard way that we needed additional tools to remove them.

Not all print files you find need added support, however, because some people are super-clever and have remixed other creations to enhance them without the need for supports. But if you're not a designer, trust the original artists and whatever settings the slicing software recommends. It also flags up warnings if it predicts your print will fail, which is incredibly useful for saving you time, frustration and materials.

3. Filament options

Speaking of materials, it sounds silly, but we've recently learned that you don't need to use the manufacturer's filament (although it is advised) with your 3D printer. We've only been using the supplied own-brand filament while getting started, and this has been great for helping the learning process, but there are plenty of alternatives with excellent reviews that we're really excited to try out next.

For example, you can get silk filament, glow-in-the-dark filament, and even dual-colour rainbow filament from Amazon sellers such as Eryone, and Isanmate, which have each had thousands of positive reviews and have been used by others with our exact same printer without any issues reported.

4. Pausing

Another thing that might sound obvious to some but was a complete learning curve for us was understanding how to stop a 3D printer mid-print without losing your masterpiece. Most 3D printers are pretty noisy when the fan speed is set to 100%, and the office room is only metres away from a bedroom, which means you'd be up all night if the printer was left running throughout the night, which considering the length of many print projects, isn't out of the question.

The solution we found was to pause the print (there's a button on our printer's display screen) and then once the progress seems to have stopped, head into the printer settings and change your fan speed to 0, and the bed heat and extruder temperature to 0 as well. Next, leave your printer on – do not press stop or unplug your printer – and there you go.

A quick search online told us that it's OK to press pause on a print, then proceed to turn your printer off

» FILAMENT MODELLING

Now that you understand how your 3D printer performs and hopefully some of its characteristics, you can look at the fine art of 3D modelling. The first design consideration for anyone who works with 3D printing is overhangs.

Take a look at the *Autodesk Kickstarter* benchmark (**https://bit.ly/lxf329autodesk**). It puts printers through their paces, testing dimensional accuracy, overhang, negative features and control. It also shows XY Resonance and Z-axis alignment, which you can use to fine-tune your machine. The Overhangs part of the test shows the quality at 15, 20, 30 and 45 degrees.

As a rule, 3D printers require supports for overhangs at an angle from the base less than 45 degrees. However, check your printer test results and adjust this value accordingly. Anything less than 45 degrees will require support, and if support is required then you'll need to spend time cleaning your model. As you design, it's often worth considering the model's orientation. Often, by printing a model on its side or even upside down, you'll get the model angled in a way that minimises the need for supports. For many characters with outstretched arms and accessories that create overhangs of less than 45 degrees, it's a good idea to place simple support blocks under the model's appendages to help shorten the required support length.

QUICK TIP

We've looked at 3D printing over the issues find a guide to using the Cura software slicer in LXF294 and LX295.

Our little garage-based 3D printing studio. It's just a bit cold and smelly and full of spiders.

for the night, but only if you've initiated the microSD card that your G-code file is stored on, something we hadn't done. Not wanting to risk losing the 30-plus hours of progress on the print, we let it ride, but it's something we strongly suggest you test out on a smaller print so as not to waste filament.

Dip into resin

Before we start on resin printers: uncured resin is dangerous, and the solvents used to clean your prints can irritate the skin and burn. Use gloves and safety glasses when pouring resin and handling uncured prints. Make sure the room is well ventilated to avoid inhaling fumes. Spilled or dripped resin should be immediately cleaned with 99% isopropyl alcohol. After printing, wipe down your printer and bottles to remove smudges of uncured resin. Always keep your resin tightly sealed and safely stored out of reach.

There aren't enough YouTube tutorials in the world to prepare you for resin printing (and how messy it can get), but we really enjoyed the learning process with the Elegoo Saturn 4 Ultra. After trying out filament printing, we wanted to dive into the deep end and attempt to teach ourselves how to 3D-print models using resin. After only a week since setting up the Elegoo Saturn 4 Ultra printer, we'd learnt a lot with help from YouTube tutorials and by simply getting stuck in.

Like our first three weeks with an FDM 3D printer, there were plenty of learning curves to deal with while getting to grips with resin printing. For starters, the slicing process involves learning how to use new software, adjusting to different support structures, and ensuring you've added drainage holes to your models before printing them to prevent them from internally cracking and eventually exploding (yes, really).

Despite the experience of using the trusty filament printer, it's safe to say that printing with resin is a very different experience from printing with PLA materials,

QUICK TIP

For the best printer models take a look at Tom's Hardware that has excellent reviews anf buying guides. We took a look in LXF327 and printing technology in LXF296.

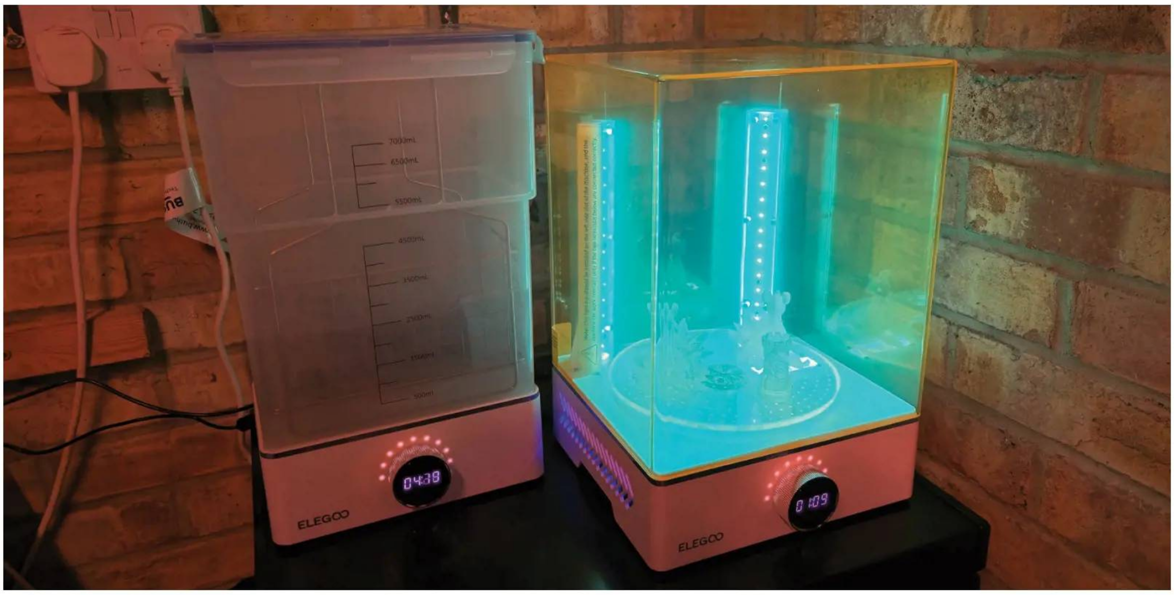
» RESINS TO BE CHEERFUL... 1, 2, 3, ERM, 4?

We chose the Elegoo Saturn 4 Ultra printer because it's a solid option for the complete resin beginner, and overall we've been happy with how easy the printer has been to set up and operate. For example, the Saturn 4 Ultra has automatic bed levelling, which we know from working with FDM printers is a huge time saver and eliminates the hassle of having to level the build plate for optimum print quality. It also comes with an AI camera included to help monitor prints, which is usually a costly extra with other competitor printers.

The touchscreen display is large and simple to navigate, without too many options or advanced settings to complicate things. The included Wi-Fi antenna is superb for allowing the printer to download and install its own firmware updates automatically, and it provides the option to send files to the printer over Wi-Fi instead of the included USB stick, too. Another great feature is the resin exposure test, which in concept allows four separate models to be exposed at different times to assess the results, although we still need to figure this out fully.

It's stunning to look at and incredibly sturdy with an enclosed build, although there are a few things that have left us scratching our heads. Firstly, there should be some kind of handle or latch for opening and closing the cover, especially since most of the time you're usually trying to avoid touching too many things while wearing gloves, to prevent spreading resin everywhere.

Secondly, prints can often fail or print poorly due to low temperatures, and it's stated on the Elegoo resin bottles that the optimum temperature for printing is around 25°C. This model doesn't have a heater, so we had to grab a portable heater for a few hours to get things up to temperature.



Here we are exposing ourselves to the world.

and you soon realise that you need to drastically change the workflow, and find a different workspace altogether to begin the journey to resin 3D printing.

Setup and prep

We started by clearing out our garage to make a working space for the new Elegoo printer, and now have the perfect space for plenty of ventilation, and handling toxic chemicals away from the usual work-from-home office space.

This is very important when working with resin, because the fumes produced during the curing process emit volatile organic compounds (VOCs), which are harmful to your health and can be poisonous if inhaled. Elegoo kindly sent us the Mars Mate Air purifier as well as its Mercury XS washing and curing stations to help with the resin printing mission, and to ensure a smooth and safe process of curing the resin prints – which become non-toxic and safe to handle without gloves once fully cured.

Other safety precautions you need to take involve wearing nitrile gloves every time you handle materials, donning a respiratory mask when the printer is on, and keeping a clean workspace to avoid contamination.

This might seem a little on the extreme side (it is not) and in hindsight, knowing the safety risks may have swayed us from attempting to learn to resin print altogether. However, nearly all the YouTube videos on the subject stress the importance of working with resin safely, and we'd rather not find out what the consequences are of taking shortcuts – painful chemical burns for one.

First resin prints

Elegoo provides a few test models on the included USB drive to use with the Saturn 4 Ultra, and the very first print was Elegoo's Rook chess piece model with a spiral castle design. It printed extremely well (although we definitely over-exposed the first layer) and gave us the confidence to try out a slightly bigger Pokémon model as our second attempt at resin printing.

The resin material that Elegoo supplied was a bottle of the standard photopolymer mixture in translucent. We researched beforehand (as good Girl and Boy Scouts, we like to be prepared) and found that translucent resin cures much faster than other coloured resins because of its easier ultraviolet light transmission.

So, with this in mind, we reduced the normal exposure time of this specific resin within the new Elegoo *SatelLite 3D Slicer*, and were happy with the results when printing some Crystal Lapras Pokémon models – although they did turn out to be pretty yellow-tinted from over-curing during post-process, which we'll keep in mind when attempting this model again soon.

We also purchased a 1kg bottle of Elegoo's grey resin, and have been using this to print mini models, including a set of Teenage Mutant Ninja Turtles figures, a Princess Peach model (we haven't removed the supports yet), as well as a large T-Rex skull, which we're very excited to wash and cure. We did have a few failed prints in the early stages, though, where we would check the build plate after a few hours to discover nothing was there.

While troubleshooting this, we used the Vat Cleaning feature on the Saturn 4 Ultra display screen, and cleaned the build plate thoroughly with isopropyl alcohol. It's worth noting that these failed prints all occurred overnight when the temperature had dropped in the garage, erm, tax-deductible resin printing lab, so perhaps the colder temperature also played a part in our failed prints. We might need an Elegoo Mini Heater to solve this problem in the long term.

Ultimately, we really enjoyed our first week of resin printing, although there's still plenty to learn and we're excited to try out some resin dyes and alcohol links with the translucent resin for some creative effects. We also need to make some PPE upgrades with a better respirator, and buy some extra storage and a sturdy bin for the garage, sorry taxman, lab! We have a feeling this might turn into a very expensive hobby pretty fast… LXF

QUICK TIP

Want to build an open source 3D printer? Check out our guide in LXF211 and we interviewed the father of the 3D printer Adrian Bowyer in LXF184! Is there anything we can't do? Oh yes, stay in print…

No one told us 3D printing could be a dangerous business!

Nate Drake inducts you into the world of cryptocurrency theft.

» STEAL YOURSELF

On the night of 21st February 2025, Bybit chief executive Ben Zhou signed in to his computer to manually approve a transaction. His crypto exchange wisely used Safe Wallet, a third-party provider that required multiple signatures to authorise transactions.

Unknown to Ben, an engineer at Safe Wallet had fallen victim to a social engineering attack earlier that month. Hackers from the North Korean group Lazarus leveraged this to exfiltrate active session tokens to access Safe Wallet's AWS account.

They were then able to inject malicious JavaScript code into the provider's interface to trick Ben into believing he was approving a legitimate transaction. Lazarus made away with around $1.5 billion in Ether.

In 2024, $2.2 billion was stolen in crypto hacks. Much of this wasn't down to elaborate supply chain attacks, so much as human error combined with malware that targets crypto wallets.

One major point of weakness is the crypto wallet seed phrase. This is useful if anything happens to your device, because the private keys used for your wallet are derived from it. However, in the wrong hands, it can be used to steal your crypto funds.

Bad actors routinely scan compromised machines for wallet files generated by popular programs like Electrum. As you'll see in our tutorial, cybercriminals can also use specialist tools to crack wallet passwords.

Luckily, help is at hand. Hardware wallets like the Trezor Safe 3, which we review this issue, store private keys securely using a dedicated security chip.

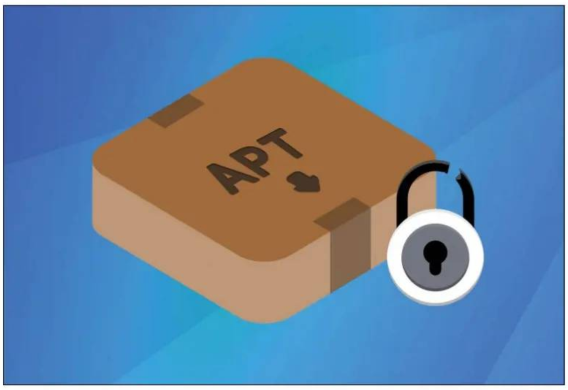
New key for Kali Linux updates

A repository snafu means that Kali Linux had to freeze repos and generate new signing keys.

In its official blog post at the end of April, which we advise you to read, Kali Linux outlined why your version of Kali Linux is no longer updating with the official repositories and generating missing key errors instead. Turns out someone misplaced the signing key for the repository. It happens, we've all done it, but you'd hope people kept closer tabs on these things…

The only solution for Kali was to freeze the repository and generate a new signing key. The annoying fallout for Kali users is that it means everyone needs to manually update the key on their installs. If you haven't already seen the detailed blog post from Kali on what to do, go to **www.kali.org/blog/new-kali-archive-signing-key/**.

While we're here, we'll also point out that Kali 2025.01 was released, and as always with its annual refreshes, there's a cool new look for 2025, including some more funky community themes worth checking out. It bumps the KDE Plasma desktop to 6.2 and if you like it lightweight, the Xfce one to 4.20.



We've all had a heavy night out and lost our keys!

CREDIT: Kali

CVE threat

Funding almost pulled.

The Common Vulnerabilities and Exposures (CVE) programme has been running for 25 years and in April almost lost its government grant. Fortunately, the US Cybersecurity and Infrastructure Security Agency (CISA) announced an 11-month extension, kicking the can down the road to March 2026. Read more at **https://bit.ly/lxf329cve**.

CVE®
Common Vulnerabilities & Exposures

How else will you know about software vulnerabilities?

Curing rootkit

Invisible to security.

A new rootkit attack called Curing has been released. It bypasses most existing security monitoring as it doesn't use any syscalls. Introduced in kernel 5.1, io_uring optimises I/O transfers without syscalls – this enables a client/server attack to make filesystem transfers invisibly to security tools. Find out more at **https://github.com/armosec/curing**.

Tux, what are you doing?

CREDIT: CVE, Magictorch

Trezor Safe 3

Nate Drake is a regular Scrooge McDuck as he stows his precious crypto coins in Trezor's mid-range cryptocurrency hardware wallet.

IN BRIEF

Bitcoin hardware wallets' USP is that they shield the private wallet keys from the internet by storing them on a separate device. The Trezor Safe 3 is fully open source with a dedicated security chip. The bundled suite makes device setup and configuration easy. You can even buy more crypto from within the app.

SPECS

CPU: 180MHz embedded ARM processor (Cortex M4)
Size: 59x32x 7.4mm/14g
Ports: USB-C
Crypto: BTC, ETH, LTC, XRP, all ERC-20 tokens

In March 2025, Microsoft issued a warning about the StilachiRAT virus, which focuses on stealing stored credentials in the *Chrome* browser to compromise crypto wallets.

As you'll see in this month's tutorial, this has become a growing trend. It's relatively easy for bad actors to access data like Bitcoin software wallets.

This is where Trezor steps in with its line of hardware cryptocurrency wallets. These devices essentially operate as a small, single-purpose computer to store the private wallet keys. Users deploy a cable and specialist software to access the device and approve transactions. As the computer never has direct access to the private keys, in theory it's much harder for hackers to exfiltrate them.

In reality, hardware wallets can be compromised with time and effort. In 2020, cryptosecurity firm Unciphered found a way to physically hack into the previous Trezor model T hardware wallet and recover the wallet keys by dumping the flash memory.

The Trezor Safe 3 addresses this with a dedicated Secure Element security chip. This acts as a gateway between the user and the device by storing the PIN code securely. This makes it much harder for bad actors with physical access to the device to recover the PIN and thereby unlock the wallet.

You can set the PIN and configure basic options by installing the *Trezor Suite,* which is available as an AppImage for Linux. This software, as well as the firmware used in the Trezor Safe 3, is fully open source.

For extra peace of mind, on opening the box, users have to remove the security seals over the USB-C port. The suite then prompts you to confirm that it hasn't been tampered with before continuing.

The suite next prompts you to decide what firmware you need. There's a universal version that supports hundreds of cryptocurrencies, or a Bitcoin-only version.

Once this is done, the suite performs a series of checks to ensure that the security chip and other wallet components are safe to use. You can then either create a new wallet or recover an existing one to the device.

If you choose to create a new wallet, you're offered the choice between a single-share or multi-share backup. Wallets use a 20-word backup seed. This is in contrast to the BIP39 specification used by popular software wallets like *Electrum,* which default to 12 words. However, this makes switching between single and multi-shares simpler.

The individual words in the wallet seed phrase appear on the Trezor Safe 3's mini screen. You can then back this up by writing it down on one of the specially supplied cards that come with the wallet. At this stage you can set a PIN, as well as enable view-only, so you can check your crypto balance from the suite when the device isn't connected.

TREZOR
Trezor Safe 3
command
option
control
fn

Trezor devices store the crypto wallet private keys securely on the device so they can't be accessed or copied by malware.

When you reconnect, you use the device buttons to enter the PIN. You can then perform activities like buying more crypto. The suite integrates with a number of popular exchanges. Before generating a payment link, it also displays the payment address. It then asks you to check the device screen, where the same address should be displayed. You can then manually confirm that the addresses match to complete the purchase.

Trezor Suite's device settings also contain extra security features. From here, you can set a passphrase to encrypt your crypto wallet. This is required along with your PIN each time you unlock the Trezor.

You can also set a wipe code to destroy all data on the device once entered. The suite even supports routing connection through Tor, though when we did this we found we couldn't check our BTC balance. LXF

VERDICT

DEVELOPER: Trezor
WEB: https://trezor.io
PRICE: $79

FEATURES	8/10	EASE OF USE	9/10
PERFORMANCE	8/10	VALUE	8/10

The Trezor Safe 3 provides solid protection against crypto-stealing malware without breaking the bank. Setup is simple, as are crypto purchases.

» Rating 8/10

ELECTRUM

Credit: https://electrum.org

Burgling Bitcoins

Nate Drake invites you to his crypto-heist training school, as he discusses how to steal Bitcoin wallets and crack passwords, just for fun!

OUR EXPERT

Nate Drake is a tech journalist specialising in cybersecurity. He once stored his Bitcoin in a paper wallet, only to find his mother had scrawled her shopping list over the back of it.

During the first quarter of 2025 the estimated losses of crypto hacking were estimated at over $1.6 billion. Around 92% of this was from crypto exchange Bybit. North Korean hacking group Lazarus was able to steal around $1.5 billion in Ethereum tokens.

It did this by compromising a third-party provider, then tricking the CEO into transferring funds from a cold wallet to one the hackers controlled.

Even if you're not running a multi-billion dollar exchange, your cryptocurrency could still be at risk if it's not properly secured.

The best solution for people who take their crypto seriously is to use a hardware wallet like the Trezor Safe 3. As the wallet's private keys are never exposed to the internet, it's harder for bad actors to steal them.

If you don't feel that a hardware wallet is worth the trouble and expense, this guide is for you. Here we'll create a crypto wallet using Ethereum for testing purposes. We'll then guide you through some basic steps hackers use to steal your funds.

Set up your wallet

While hacking is always fun, we cannot emphasise strongly enough that you shouldn't use a real cryptocurrency wallet for this tutorial.

Fortunately, popular Bitcoin wallet software *Electrum* has a testnet mode. As the name suggests, this is an alternate Bitcoin blockchain used for testing purposes. The coins used by testnet have no value, which makes them perfect for carrying out activities like testing wallet security.

To get started visit **https://electrum.org** and choose to download the Linux AppImage. This is designed to run on virtually every version of Linux, though you may need to install libfuse2 first via the terminal to do so:

```
$ sudo apt install libfuse2t64
```

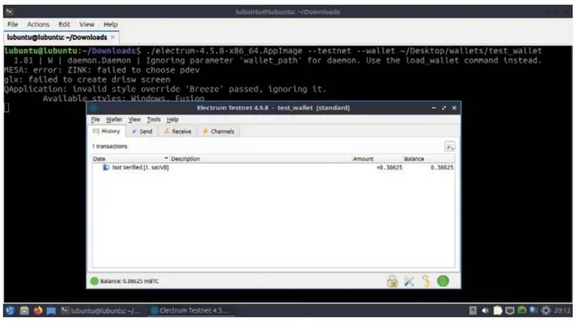
Once the download is complete, use *cd* to switch to the AppImage location, then run it using the **--testnet** parameter – for example:

```
$ ./electrum-4.5.8-x86_64.AppImage --testnet
```

Once *Electrum* launches, choose Next then set a meaningful name for your wallet, such as **test_wallet**.

On the next screen, choose a standard wallet, then click Create New Seed. At this point you need to write down the seed created for your test wallet. Usually you'd need to stow this in a safe place, because in the wrong hands it could be used to steal your funds.

Because you're doing this for testing purposes, keep the seed by your side, then enter it again on the next screen. *Electrum* now prompts you to choose a password. Leave this field blank for now and just select Finish.



```
lubuntu@lubuntu:~/Downloads$ ./electrum-4.5.8-x86_64.AppImage --testnet --wallet ~/Desktop/wallets/test_wallet
  1.81 | W | daemon.Daemon | Ignoring parameter 'wallet_path' for daemon. Use the load_wallet command instead.
MESA: error: ZINK: failed to choose pdev
glx: failed to create drisw screen
QApplication: invalid style override 'Breeze' passed, ignoring it.
        Available styles: Windows, Fusion
```

Electrum Testnet 4.5.8 - test_wallet [standard]

1 transactions

Date	Description	Amount	Balance
Not Verified [1. sat/vB]		+0.38625	0.38625

Balance: 0.38625 mBTC

If a wallet's unencrypted, it can be stolen and opened by corresponding wallet software on a live Linux distro.

Once the main *Electrum* window launches, go to View and tick Addresses. You can now move to the corresponding tab to find a payment address for your test wallet. Right click on one of these and choose Copy > Address.

You now need to transfer some test Bitcoins to your wallet from a faucet. We recommend **https://coinfaucet.eu/en/btc-testnet/**.

Paste in the payment address to receive your test Bitcoins and wait for the transaction to confirm.

Stealing the crypto

Once you've confirmed safe receipt of your test BTC, close down *Electrum*. The best way to show how easy it is to steal wallet keys in these situations is to use a live DVD or USB to boot a different version of Linux on your machine. For this article, we used Lubuntu 24.04.

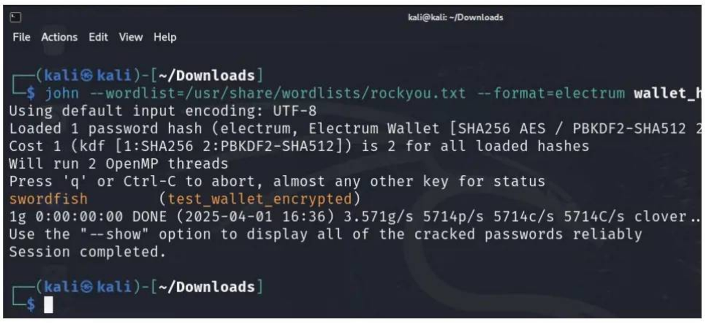
Once the live desktop loads, your own machine's hard drive usually appears as a desktop shortcut. You can then open this to access the device's files, assuming the drive is unencrypted.

By default, *Electrum's* wallet files are stored in **.electrum/wallets** in the **home** folder. (Press Ctrl+H to view hidden files and folders.) Copy this wallet's folder to the desktop of your live distro.

Next, repeat the steps outlined above to download the AppImage of *Electrum*. You can then have your copy of *Electrum* open the wallet using the **--wallet** command-line parameter – for example:

```
$ electrum-4.5.8-x86_64.AppImage --testnet --wallet ~/
Desktop/wallets/test_wallet
```

At this stage, as the hacker, you now have full control of the wallet. You can even go to Wallet >



```
┌──(kali㉿kali)-[~/Downloads]
└─$ john --wordlist=/usr/share/wordlists/rockyou.txt --format=electrum wallet_h
Using default input encoding: UTF-8
Loaded 1 password hash (electrum, Electrum Wallet [SHA256 AES / PBKDF2-SHA512 2
Cost 1 (kdf [1:SHA256 2:PBKDF2-SHA512]) is 2 for all loaded hashes
Will run 2 OpenMP threads
Press 'q' or Ctrl-C to abort, almost any other key for status
swordfish        (test_wallet_encrypted)
1g 0:00:00:00 DONE (2025-04-01 16:36) 3.571g/s 5714p/s 5714c/s 5714C/s clover..
Use the "--show" option to display all of the cracked passwords reliably
Session completed.

┌──(kali㉿kali)-[~/Downloads]
└─$ █
```

Dictionary attacks of common passwords can easily break into encrypted crypto wallets. Unconventional passwords can also succumb to brute-forcing methods.

Private Keys > Export from *Electrum* to transfer the keys to a different wallet if you wish.

Cracking the crypto

While the above method to exfiltrate wallets works perfectly well in itself, it's predicated on a number of assumptions.

The first of these is that the *Electrum* wallet owner chose not to set a password during initial setup. This can hugely increase wallet security by protecting it with 256-bit AES encryption. Without the correct password, even if a bad actor were to steal the wallet file – using malware, for example – they wouldn't be able to access your funds.

Still, in these cases the wallet is only as secure as the password. Weaker passwords can be cracked by specialist programs like *John the Ripper.* This exists in the repositories of most Linux distros but for the sake of simplicity, we recommend that you download Kali (**http://kali.org**) for the next part of this tutorial, as it contains *John the Ripper* and associated data.

Next, reopen *Electrum* and choose Wallet > Password to set a passphrase to encrypt the wallet. Close *Electrum* then copy the now-encrypted wallet file to your Kali install using a new wallet name – for example, **test_wallet_encrypted**.

John the Ripper can't crack the encrypted wallet directly, so first you need to use *electrum2john* to extract the password hash and output it to a file.

```
$ electrum2john test_wallet_encrypted > wallet_hash.txt
```

Now you have the wallet password hash, your first step should be to run a dictionary attack. Kali has a compressed form of the RockYou word list, which uses word lists containing 14,341,564 unique passwords, based on a real data breach. To unpack this, run:

```
$ sudo gzip -d ~/usr/share/wordlists/rockyou.txt.gz
```

You can now have *John the Ripper* try to extract the password from the wallet hash using a dictionary attack specifically configured for *Electrum*:

```
$ john --wordlist=/usr/share/wordlists/rockyou.txt
--format=electrum wallet_hash.txt
```

If the password is common or found in the dictionary, it will likely display in seconds. If you're running these tests on multiple wallets, you can also display recovered passwords with the **--show** parameter – for example:

```
$ john --show wallet_hash.txt
```

Brutal tactics

If you downloaded our test encrypted wallet earlier, you probably weren't surprised to find that *John the Ripper* cracked it in seconds, considering we adhered to the TV trope 'the password is always swordfish'.

Electrum warns users against weak passwords, so it's likely that conscientious users would choose an alphanumeric password containing a combination of letters and numbers.

This is why *John the Ripper* also supports incremental mode. This is one of the tool's most powerful features, because it can essentially try all combinations of characters until it hits upon the right password – for instance:

```
$ john --incremental --format=electrum wallet_hash.txt
```

The success of these kinds of brute-force cracking techniques is determined by the strength of the password. In the case of the one we chose, 'xunil3', our Kali virtual machine was able to recover it in around 20 minutes. This likely would only have taken seconds if we'd installed Kali on bare metal.

Crypto conclusions

After following the steps in this tutorial, our hope is that you'll realise the safest way to store your cryptocurrency is in a hardware wallet.

However, if you have to use a software wallet like *Electrum*, there are steps you can take to stay safe.

First of all, install *Electrum* and create your wallet on a dedicated, air-gapped machine that uses full-disk encryption.

If this isn't feasible, consider instead using a virtual machine with the network adaptor disabled, so your wallet files can't be stolen remotely.

During setup, make sure to set a strong wallet password. We recommend Diceware (**https://diceware.dmuth.org**) for generating high-entropy but easy-to-remember passphrases. LXF

QUICK TIP

We've included steps in this tutorial to access the Bitcoin Testnet, so you can test your wallet security safely and ethically. If you want to save time, you can download some sample wallet files from Nate's GitHub page: https://bit.ly/lxf329crypto. The encrypted wallet uses the password 'swordfish'.

» BRAINSTORMING WALLETS

As most cryptocurrencies rely on asymmetric encryption, certain users deploy a brain wallet to store cryptocurrencies. This is fairly simple. First, think of a word or phrase, such as 'correct horse battery staple', then hash it with SHA-256. In the terminal, type:

```
$ echo -n "correct horse battery staple" | sha256sum
```

In theory, the resulting hash can be used as a payment address to receive Bitcoins. In practice, this is a very bad idea. Security researchers have created tools to test common brain wallet phrases and steal cryptocurrencies. These days, such tools can test 18 million potential passphrases on AWS for less than a dollar.

Of course, if you're using software like *Electrum,* there's no reason why you can't memorise your seed phrase. However, these words are chosen at random – for example, 'witch collapse practise feed shame open pear creek road cloth ice least'.

The best way to memorise this is to use the Method of Loci. This involves imagining a place you know well, such as the house you grew up in, then placing people or objects in various locations.

In the above example, you might open your front door to be greeted by a WITCH complete with green skin and a pointy hat, only for her to clutch her chest and COLLAPSE in the front hall. Stepping inside you might see your parents dressed in tennis whites as they PRACTISE their serve, and so on.

THE BEST NEW OPEN SOURCE SOFTWARE ON THE PLANET

HotPicks

Nautilus » Moonshine » Ethereal (Wireshark) » Bluefish » Webalizer » Krusader » Xine » Chromium BSU » Defendguin » GnuCash » TeXmacs

Neil Mohr travels back in time to dig up the earliest HotPicks and check on their progress.

FILE MANAGER

Nautilus

Version: 0.5 (January 2001)
Web: https://gitlab.gnome.org/GNOME/nautilus

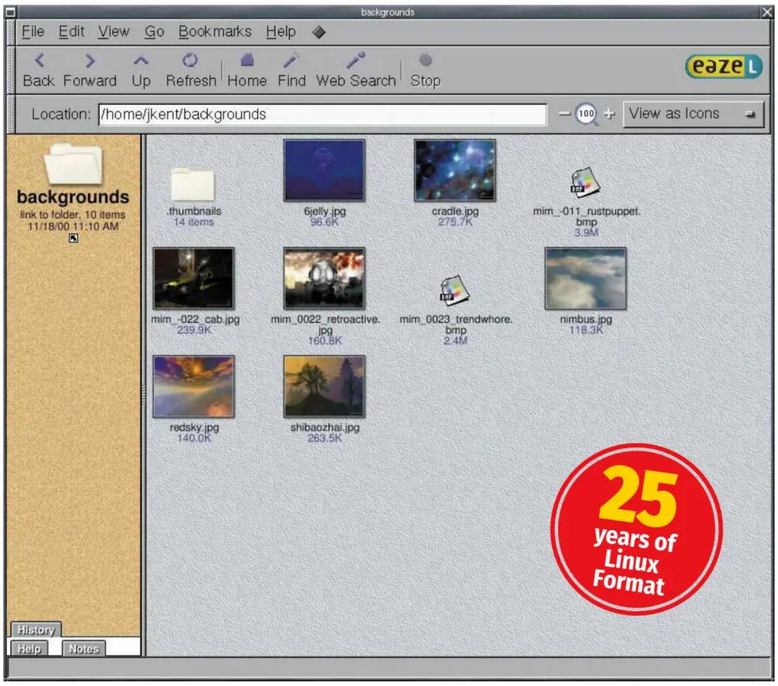
We first looked at *Nautilus* back in **LXF010**, the January 2001 issue, and things could get a little confusing because what was called *Gnome Nautilus* back then is now known as *Gnome Files*. We guess that's so people understand what it does, though we imagine the original thinking was that it helps you plumb the depths of your filesystem, like the eponymous submarine. This particular issue would have been written around December 2000, and that's handy to know because *Nautilus* version one wasn't released until March 2001 and was then absorbed into the Gnome project. Back then, we had the following to say about it:

Nautilus is a file manager (or Desktop Shell, as Eazel – the developer – likes to refer to it) on steroids, that has been designed to work on the HelixCode Gnome desktop. Currently it is available as a preview release, so it is therefore a little bit rough around the edges, but is showing a lot of promise.

As this is still a preview you should expect some program crashes to occur. *Nautilus* development is looking very good for the future; it is expected to replace the existing default file manager in the next release of Gnome and is more user-friendly than its predecessor ever was. It's fairly stable and, occasional crashes aside, is also very usable. Along with HelixCode, *Nautilus* goes some way in helping to make the Gnome environment more polished and user-friendly. Overall, this is a very eye-catching application, with some interesting features. Whether you feel that all these bells and whistles make sense as part of a desktop file manager or not, you will be impressed by the way *Nautilus* functions and its suave good looks. Get it now.

HelixCode, in case you were wondering, was a company created to originally support Gnome Desktop development. It became Ximian (a founding member of Gnome) very early on and was later acquired by Novell. There are some old Ximian website fragments on **Archive.org** (**https://bit.ly/lxf329helix**) that make an interesting historical read straight from the founders' mouths.

As you'd expect, *Gnome Nautilus* was developed in lockstep with the Gnome desktop, so *Nautilus 2.0* was shifted to *GTK+ 2.0* in June 2002 and received a major interface overhaul to bring it in line with the Gnome 2.0 interface for *Nautilus 2.2* in February 2003. *Nautilus 2.3* heralded the biggest shift from the old-style Windows 95/98/2000 spatial windows to the fancy new browser-style single-window, multi-panel design in March 2010. This was relatively quickly followed by the shift to Gnome 3.0 and *GTK3* in April 2011 that caused the start of all the desktop ruckus and projects such as Linux Mint Cinnamon breaking away. *Nautilus* received a complete interface overhaul for modern aesthetics and interfaces. *Gnome Nautilus* was renamed *Gnome Files* for the 3.6 release in September 2012, and it also gained another interface refresh that refined the original 3.0 design to pretty much what remains today.

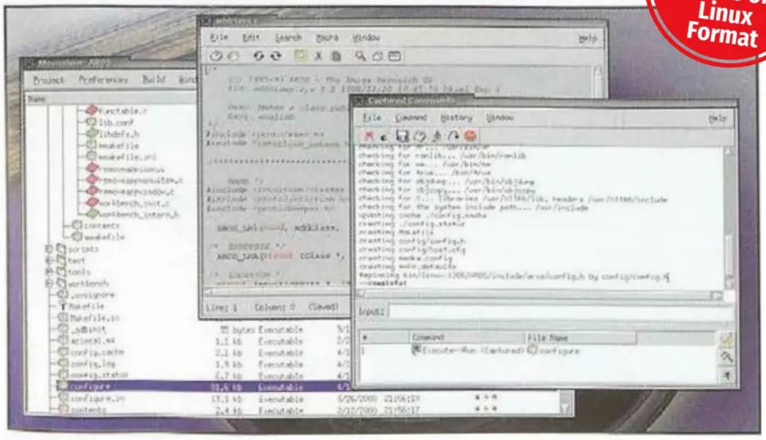

backgrounds
File Edit View Go Bookmarks Help
Back Forward Up Refresh Home Find Web Search Stop
eazel
Location: /home/jkent/backgrounds
View as Icons
backgrounds
link to folder, 10 items
11/18/00 11:10 AM
.thumbnails
14 items
6jelly.jpg
96.6K
cradle.jpg
275.7K
mim_-011_rustpuppet.bmp
3.9M
mim_-022_cab.jpg
239.9K
mim_0022_retroactive.jpg
160.8K
mim_0023_trendwhore.bmp
2.4M
nimbus.jpg
118.3K
redsky.jpg
140.0K
shibaozhai.jpg
263.5K
History
Help
Notes
25 years of Linux Format

From 2001: Graphic files viewed as thumbnails. Do we really need to tell you how useful this feature is?

IDE

Moonshine

Version: 0.1 (May 2000)
Web: https://moonshine-ide.com



Linux can have graphical IDEs, too. It's not all shell commands and switches, you know!

Now let's whisk you back to **LXF001**, published in May 2000. Of the *HotPicks* listed that issue, only *Moonshine* is still in active development. The other option was *Grip*, a CD player and ripper that you can still get (**https://sourceforge.net/projects/grip/**) but it may no longer be maintained. Back then, we had the following to say about *Moonshine*:

Program development on Unix-like platforms has been traditionally been done with shell tools, command-line-driven compilers, configure and make scripts. This can be rather off-putting to a developer who is used to the graphical IDEs and *Visual*-type environments available on other platforms. *Moonshine* is a package that attempts to redress the balance.

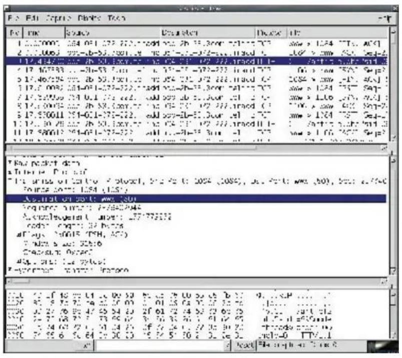
Moonshine is a language-independent graphical IDE for X, built with *Qt*, It is shipped with modules geared for C++, OT, *Qt2* and web development. These are just configuration files that describe the look and feel of *Moonshine* and can be adjusted, whatever language you are developing in. The documentation describes this in detail and the customisation process isn't taxing.

The main *Moonshine* window is the project browser and provides a tree list of your project's components. Context-sensitive menus launch actions according to the file type of a component. For example, text files can be edited with the built-in editor, *Brew*. This is a basic but nimble editor with syntax highlighting and a macro facility. A neat feature of *Moonshine* is Capture. The output of any shell commands it runs can be redirected to display in a *Moonshine* window, which supports syntax highlighting, cut and paste, and a review buffer. *Moonshine* also keeps a history of all the commands it executes. It is a well-thought-out package with plenty of scope for improvement (a drag-and-drop makefile would be nice). It is ideal for avoiding culture shock when beginning to program on Linux.

NETWORKING

Ethereal (Wireshark)

Version: 0.8.14 (Jan 2001)
Web: www.wireshark.com



Ethereal can perform a comprehensive analysis of your network.

Cast your minds back to **LXF326** and the interview with the *Wireshark* creators. *Wireshark* started life as *Ethereal*, which was in *HotPicks* in **LXF010**. It was eventually renamed due to trademark issues, but back then we had this to say:

Ethereal is a GUI network analyser that allows you to interactively browse network packet information from a live network or a capture file. It understands network capture files that were generated by other network analysers, such as *Snoop* and *tcpdump*. *Ethereal* needs to be run as root in order to capture all packets on the network that you wish to analyse.

When the program is launched, you are presented with three panels displaying a summary of the packets received, a detailed description of each, and a hex display of their contents. Highlighting a packet within the summary panel displays the detailed information and hex display of it in the associated panel. Within the detailed description you can drill down into the packet by selecting the + next to the option of interest. If you highlight one of the lines in the detailed summary, this area of the packet is displayed in the hex display panel.

Aside from standard network analysis, *Ethereal* also lends itself to other uses. For instance, it could be used as an intruder detection system (IDS) by configuring the filters to look to traffic that it considers suspicious.

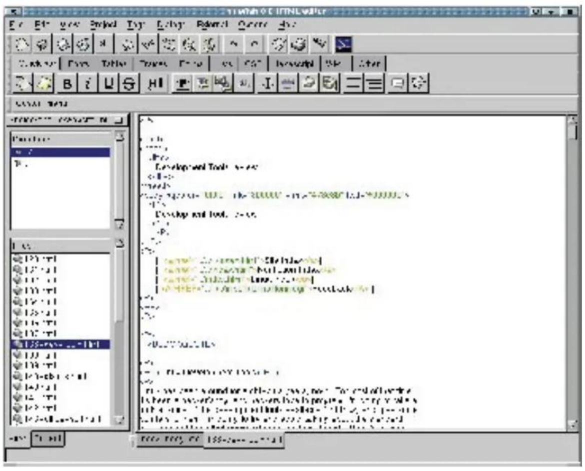
There is not much documentation and there are few examples that you can learn from. This is a shame, as *Ethereal* is a very impressive product. It's a little temperamental, crashing from time to time – especially when looking at captured data. But this is to be expected from a product in the development phase.

Ethereal is an impressive, usable product. Because of its pre-release status, its use for critical work is not recommended at present. Once the stability issues have been resolved, it should prove indispensable.

EDITOR

Bluefish

Version: 0.8 (February 2001)
Web: https://bluefish.openoffice.nl



Colour coding improves the legibility of your code.

An interesting aspect of looking back at projects is how they can start as one thing and over time go in another direction. In **LXF011**, we looked at *Bluefish,* a straight HTML editor, something that was in big demand. Jump forward 25 years, and *Bluefish* is still maintained but has evolved into a more generic editor for most languages. The write-up went:

Bluefish is a different HTML editor for Linux. Unlike *Quanta* (now defunct), it isn't tied to a specific desktop environment (KDE) – all it needs is X11 and the *GTK* widget set. If you have an up-to-date Gnome desktop environment, all the libraries you need to run *Bluefish* are present, but it isn't a Gnome application as such, and doesn't need all the Gnome extras.

Like *Quanta, Bluefish* presents a multidoc view of your work: edit pane at right, directory window top-left, and list of files bottom-left. However, *Bluefish* makes no pretence at WYSIWYG, even to the extent of providing a non-editable preview mode; to preview a page, you need to feed it to an external browser (such as *Netscape)* via the appropriate menu option. One annoyance: neither app seems to support preview options for different browsers – vital when developing content that needs to look good on *Lynx* and Mozilla.

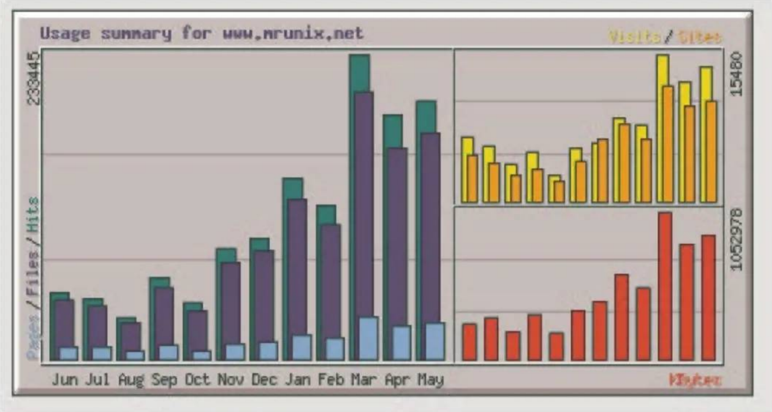
It's in the documentation arena that *Quanta* shows an edge over *Bluefish. Bluefish* is not documented. When writing files using a structured format like HTML, CSS1 or PHP, you need a language reference to hand. *Bluefish* is still a work in progress, and it seems that documentation is way down the priority list.

Bluefish shows promise. Add documentation and point help, fix the rough edges with project handling, and it'll be a powerful and productive HTML editor. Being *GTK*-based, it can be turned into a Gnome app relatively easily. With a bit of work, it will rival *Quanta*.

LOG ANALYSIS

Webalizer

Version: 2.0.1 (March 2001)
Web: https://webalizer.net



Output from the logs produced by the server for The Webalizer's site.

We suspect anyone who's played around with web servers even casually will recognise this tool. Partly as it's been absorbed into various cloud-based and web-based control panels for basic log statistics. It should be telling that even in **LXF012** it was at version two and was the default Apache web traffic tool. Our write-up back then went:

Anyone who runs a web server – be it Apache, Roxen or a smaller alternative – keeps tabs on their log files, checking for problems or sinister activity that may pose a threat to the system. As these mount up to enormous files that aren't easy on the human eye, programs exist to process them into something more intelligible.

The *Webalizer's* author started his project as a result of dissatisfaction with the dire performance and erroneous results of similar tools. Starting as a simplistic Perl script, in the last few months it has seen some major development work and now claims to be used by thousands of systems around the world. If you've downloaded the binary TAR.GZ package from the website, you can simply copy over the executable held within to an appropriate location. A sample configuration file is also supplied as a base. To compile, you'll need the GD graphics library installed (for creating the PNG graph images), and from there it's just a case of following the usual autoconf **./configure** process.

The *Webalizer* is more than happy working with gzipped logs, has DNS lookup capability (if compiled in) and boasts a whole host of other features, including yearly, monthly, daily and even hourly usage statistics. There is also the ability to display usage by URL, referrer, browser, username and location. Output is generated as an HTML file, and a PNG graph image is produced for a more visual representation. The *Webalizer*, by its very nature, is hardly the most exciting utility, but it does a very specific job solidly and is worth considering for those running a web server and needing regular stats.

FILE MANAGER

Krusader

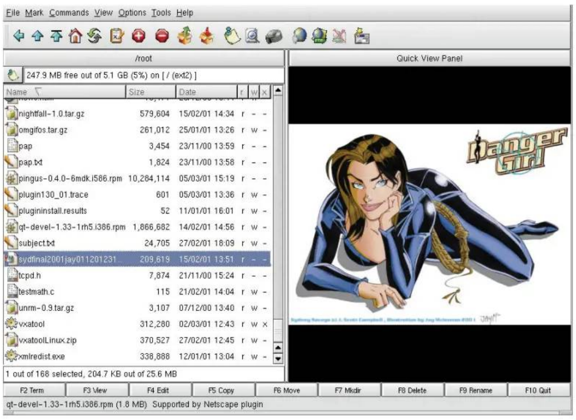
Version: 0.79 (April 2001)
Web: https://krusader.org

We still use *Krusader* for server file transfers here in 2025 and as this write-up points out, you can't beat the two-pane design for simple file management. We'll also admit to constantly confusing the also still developed *Konqueror* (absorbed into the KDE project for its sins) and *Krusader*. So, it's probably best we're closing down to stop this ongoing embarrassment! Let's wibble-wobble back to 2001…

Some people believe you can't top the old twin view style of file manager. These people may be right. The default KDE2 file manager, *Konqueror*, is superb in many ways, but if you like a twin-view file manager, it leaves some things to be desired – mainly the fact that you only get one URL/directory line at the top, and it can be confusing as to which view it relates to.

Krusader attempts to appease the luddite in you by delivering a fully KDE2-ised *Midnight Commander*-style back-to-basics file manager, but with plenty of enhancements. In some ways, it's the little things that make the difference. *Krusader's* information bar tells you the size and free space on the drive the current directory is situated on, plus the mount point and type of partition it's on. This is the sort of stuff you want a file manager to be able to do. Going one stage further, *Krusader* features MountMan, which shows a list of mounted partitions, and allows you to mount or unmount them (although supermount partitions cannot be mounted and unmounted in this way, currently).

If you need to FTP a lot, *Krusader* is every bit as capable as *Konqueror* (though the connection progress display is a bit tiresome). There is a connection manager for storing usernames and passwords if required, and while this is currently limited to FTP, there are plans to support Samba volumes via this method, too. The only real problems are a lack of documentation and a few quirks with the way archives are handled, which we're sure will also be sorted out soon.



247.9 MB free out of 5.1 GB (5%) on [/ (ext2)]

Name	Size	Date	r	w	x
nightfall-1.0.tar.gz	579,604	15/02/01 14:34	r	-	-
omgifos.tar.gz	261,012	25/01/01 13:26	r	w	-
pap	3,454	23/11/00 13:59	r	-	-
pap.txt	1,824	23/11/00 13:58	r	-	-
pingus-0.4.0-6mdk.i586.rpm	10,284,114	05/03/01 15:19	r	-	-
plugin130_01.trace	601	05/03/01 13:36	r	w	-
plugininstall.results	52	11/01/01 16:01	r	w	-
qt-devel-1.33-1rh5.i386.rpm	1,866,682	14/02/01 14:56	r	w	-
subject.txt	24,705	27/02/01 18:09	r	w	-
sydfinal2001jay011201231…	209,619	15/02/01 13:51	r	-	-
tcpd.h	7,874	21/11/00 15:24	r	-	-
testmath.c	115	21/02/01 14:04	r	w	-
unrm-0.9.tar.gz	3,107	07/12/00 13:40	r	w	-
vxatool	312,280	02/03/01 12:43	r	w	x
vxatoolLinux.zip	370,527	27/02/01 12:45	r	w	-
xmlredist.exe	338,888	12/01/01 13:04	r	w	-

1 out of 168 selected, 204.7 KB out of 25.6 MB

qt-devel-1.33-1rh5.i386.rpm (1.8 MB) Supported by Netscape plugin

Krusader also includes a one-pane preview mode for most file types

---

DVD PLAYER

Xine

Version: 0.4 (May 2001)
Web: http://xine.sourceforge.net

This isn't maintained any more, so we shouldn't strictly be listing it, but it is still available and, at the time, it was an important release that enabled DVD playback on Linux systems. A DRM-based headache that still persists in different ways with streaming services. The review in **LXF014** postulates that reason for people still using Windows…

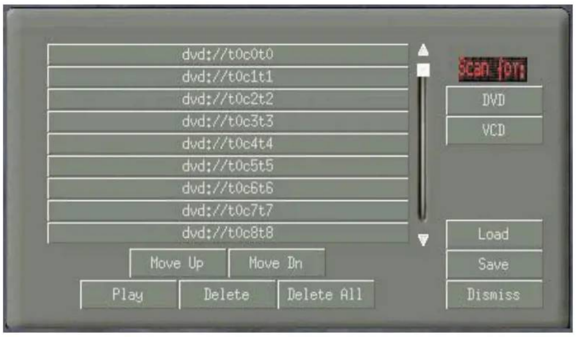
People hold on to their Windows installations for a number of reasons: access to *Cubase;* the need to play *Quake III Arena* the day it came out; the desire to watch *The Matrix* on a pin-sharp 19-inch monitor. All these are great reasons, but each one is being eroded.

Playing DVDs under Linux has not had the happiest of histories, what with the *DeCSS* debacle and subsequent legal battle. So, you'd be forgiven for thinking that you will never be able to play your DVDs on your Linux box. Well, you're wrong and you can: *Xine* will open the door to what is often hyped as "the best home cinema experience you could have".

Xine is the DVD player we've all been praying for, and even at this fairly early stage in its development, it's looking very promising indeed. That is not to say that you can't already use this on your own system; you can, and should, to ensure that any bugs are found and fixed. This is a very stable program – we've thrown the best Hollywood can offer at it and it's still not crashed.

What *Xine* lacks is a good interface. It appears that beauty and functionality are not uppermost in the developers' minds (which, at this stage, is forgivable). It can't even display the DVD main menu screen. Instead, users are forced to select the DVD track they wish to view. *Xine* then plays the DVD from that point forward.

When you download *Xine* from the website, you will probably only be able to play a few, if any, of your DVDs. However, there is a library call libCSS (currently at version 01.0), which performs the decrypting, and a plugin for *Xine* (**xine_dvd_plugin.tar.gz** is the usual archive name for this plugin) that then unlocks and decrypts. The legal status of this plugin is debatable, but it is currently easy enough to find and install.



Choosing chapters is hardly an intuitive process.

SHOOT-'EM-UP

Chromium BSU

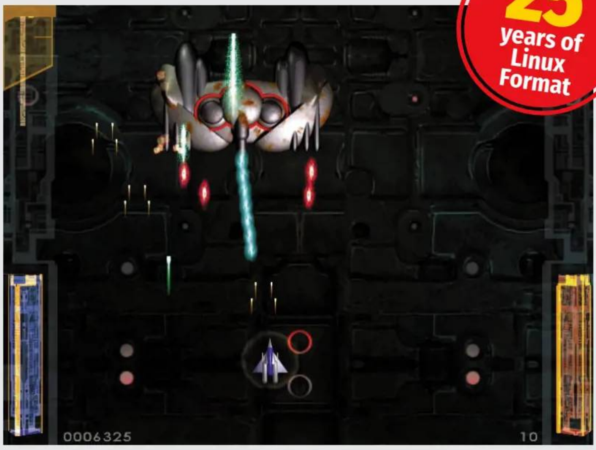
Version: 0.9 (April 2001)
Web: https://chromium-bsu.sourceforge.io

No, it's not an early *Chrome* release but one of the first games to be listed in *HotPicks*. In early issues games only made occasional appearances, until **LXF036** and the Mike Saunders period and they were every issue, we suspect it's more a case of open source tools becoming easier to develop games with. This issue and last we wrote about Simple DirectMedia Layer 3.0 for basic game development, and here's an early use of version one:

Games are good, and good games are better. This is a good game, especially if you like scrolling up screens and blasting the bejaysus out of anything you don't like the look of. Actually, this game has a fair bit more strategy than ordinary blasters of this ilk. For one thing, the enemy must not be allowed past you, or you lose a life. This leads to some interesting tactics, where it can be worth ploughing into enemies or self-destructing (which ejects all your powerups) rather than letting them through.

Chromium uses the SDL (Simple DirectMedia Layer) libraries to run – a version of the SDL libraries is included on the DVD this issue *[those were the days]* if you don't have it. This results in a graphically rich, smooth game, though it takes its toll on frame rates if you don't have an accelerated display.

Graphics levels and screen size can be adjusted, but you need an OpenGL card (with the proper drivers) to run this game properly. The music in the game is pretty good, too, but if you have your own favourite blasting tunes, you can substitute these instead. *Chromium* supports WAV files, CD tracks (the track played depends on the level you're on – for example, playing on level 2 plays track 2 from the CD), and if you have the OpenAL system set up, you can incorporate playlists with MP3s and other supported music types. A great tension reliever.



The end-of-level boss is particularly difficult to kill – this game isn't easy!

DEFENDER CLONE

Defendguin

Version: 0.0.6 (June 2001) **Web:** www.newbreedsoftware.com/defendguin

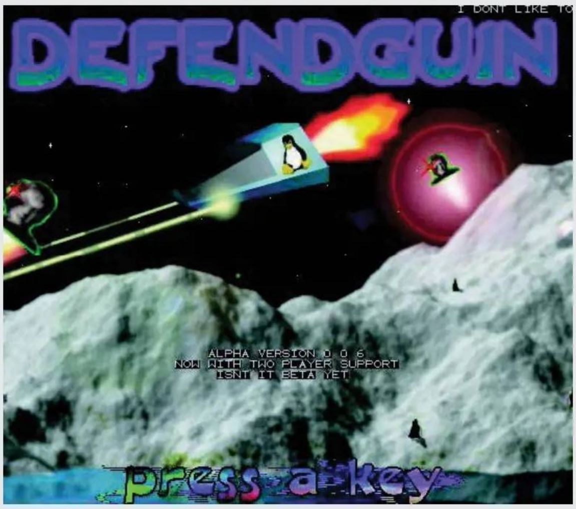
We honestly thought we'd be writing up *Tux Racer* in this section, but here we are writing about *Defendguin.* We guess penguin-based games are just the gift that keeps on giving for Linux users. Again, we might be pushing the limits of maintained here, but there was an update to *Defendguin* in 2023, which is good enough for us!

As you may have guessed from the name of this little game, *Defendguin* is a *Defender* clone with a nice twist: the aliens are, in fact, none other than a bunch of little Bill Gates clones, who are trying to capture and mutate the Tux population of the planet. Your mission is to ensure that all the Bill Gateses get terminated, and that you rescue as many Tuxes as possible. Now this is fun!

There is a great deal of satisfaction seeing one of the Bill aliens blasted into a million pieces.

The program uses the Simple DirectMedia Layer, which is designed to be a cross-platform library that provides access to the underlying frame buffer and audio devices. If you wish to install this game, you need to pop over to the website for the software at **www.libsdl.org**. The links to the site are also available on *Defendguin's* website.

As with the original *Defender* game, you have a laser and a limited number of bombs that can be used to blast all the alien Bills currently viewable on the screen. Aside from the fun of blasting up Bill Gates-a-likes, the game itself is great fun to play and quite addictive. The graphics, whilst not exactly of *Quake III* quality, do the job, and the whole game runs at a very respectable speed. For a game that the author states is still in alpha, it is very stable and no major problems were found on our test system.



A penguin-based game was bound to feature somewhere in these pages.

FINANCE

GnuCash

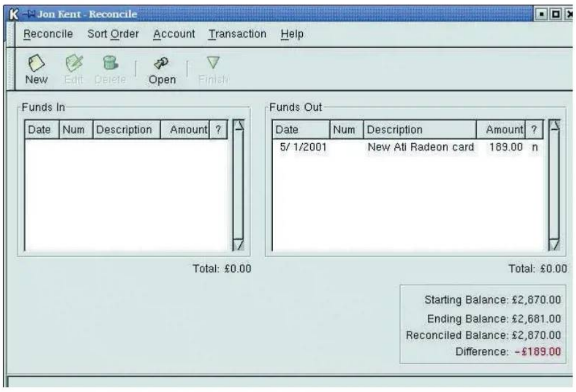
Version: 1.4.3 (June 2001)
Web: www.gnucash.org

We ran an updated review of this in **LXF320**, as the project is very much alive and kicking. The write-up from **LXF015** mentions *Gnome Office,* which was an attempt to unify a group of apps into an official Gnome office suite, but it was never a core focus of Gnome and was disbanded by October 2022.

GnuCash forms part of the *Gnome Office* suite, but like all other *Gnome Office* apps, it works perfectly well under other window environments. *GnuCash* allows you to manage all of your finances, as long as you are prepared to put time into inputting the details of all transactions and setting up new accounts as required. The interface is clean and logical, and getting starting is simple enough. If you have previously used *Quicken,* you can even import your old *Quicken* files.

The Register window is where all transactions, such as deposits and withdrawals, are logged. To enter a new transaction, enter its date, a brief description and the total amount in the appropriate column.

As *GnuCash* allows you to have both reconciled and unreconciled items logged against your account, the Register window displays two balances: Balanced and Cleared. Balanced is the state of the account assuming all items are reconciled, and Cleared shows the state of the account without unreconciled items. This feature is excellent for planning a budget, because it provides a snapshot of the account as it is, and as it will be when all payments have cleared.



Date	Num	Description	Amount	?

Total: £0.00

Date	Num	Description	Amount	?
5/ 1/2001		New Ati Radeon card	189.00	n

Total: £0.00

Starting Balance: £2,870.00
Ending Balance: £2,681.00
Reconciled Balance: £2,870.00
Difference: -£189.00

A live report from the Linux Format cash flow.

25 years of Linux Format

GnuCash has several standard reports that can be run against the accounts, such as Profit and Loss, Balance Sheet and so on. You can also write your own reports, but you need to know Scheme to do so.

GnuCash requires a lot of manual intervention, and there does not appear to be a method by which you can enter standard monthly comings and goings from your accounts, such as direct debits or salary payments. However, it is a very stable product and worth a look if you need a personal finance package.

TYPESETTING

TeXmacs

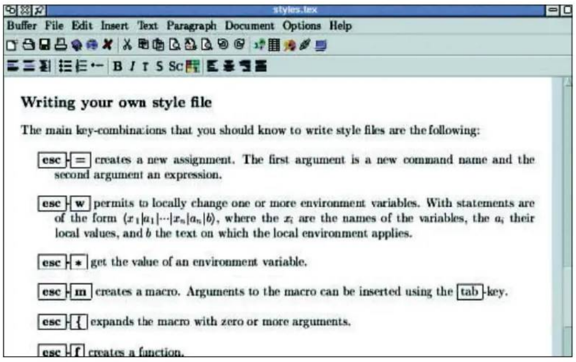
Version: 3.3.15 (June 2001)
Web: www.texmacs.org

We'd have been surprised if a historical look back hadn't mentioned *TeX* at some point, so it's good that a version of *TeX* came up in *HotPicks.* While standard documents software has absorbed some of the functions of *TeX,* it's still widely used in academia by mathematicians, scientists and engineers for its absolute flexibility with formulas. As we explained way back when in **LXF015**:

Donald Knuth, one of the pioneers of computing science, is perhaps best known for the creation of *TeX,* the mathematical typesetting package. *TeX* is a great piece of software but, even with a macro package such as *LaTeX,* it's not the easiest thing to get to grips with.

TeXmacs is more accessible, providing a WYSIWYG interface to *TeX*, more like a modern graphical word processor. The second half of the name is derived from *Emacs* but don't let that worry you. While you can program in Guile Scheme, *TeXmacs's* core functions are all available via point and click.

TeXmacs looks and feels a lot like any word processor. You can enter text, select text with mouse, cut and paste to the clipboard, choose fonts, sizes and styles, and so on. You can also insert images (vector formats like EPS and XFig are handled) and hyperlinks to documents. In conjunction with *ISpell* it even supports spell-checking. But it does a lot more.



Writing your own style file

The main key-combinations that you should know to write style files are the following:

esc-= creates a new assignment. The first argument is a new command name and the second argument an expression.

esc-w permits to locally change one or more environment variables. With statements are of the form $(x_1|a_1|\cdots|x_n|a_n|b)$, where the x_i are the names of the variables, the a_i their local values, and b the text on which the local environment applies.

esc-* get the value of an environment variable.

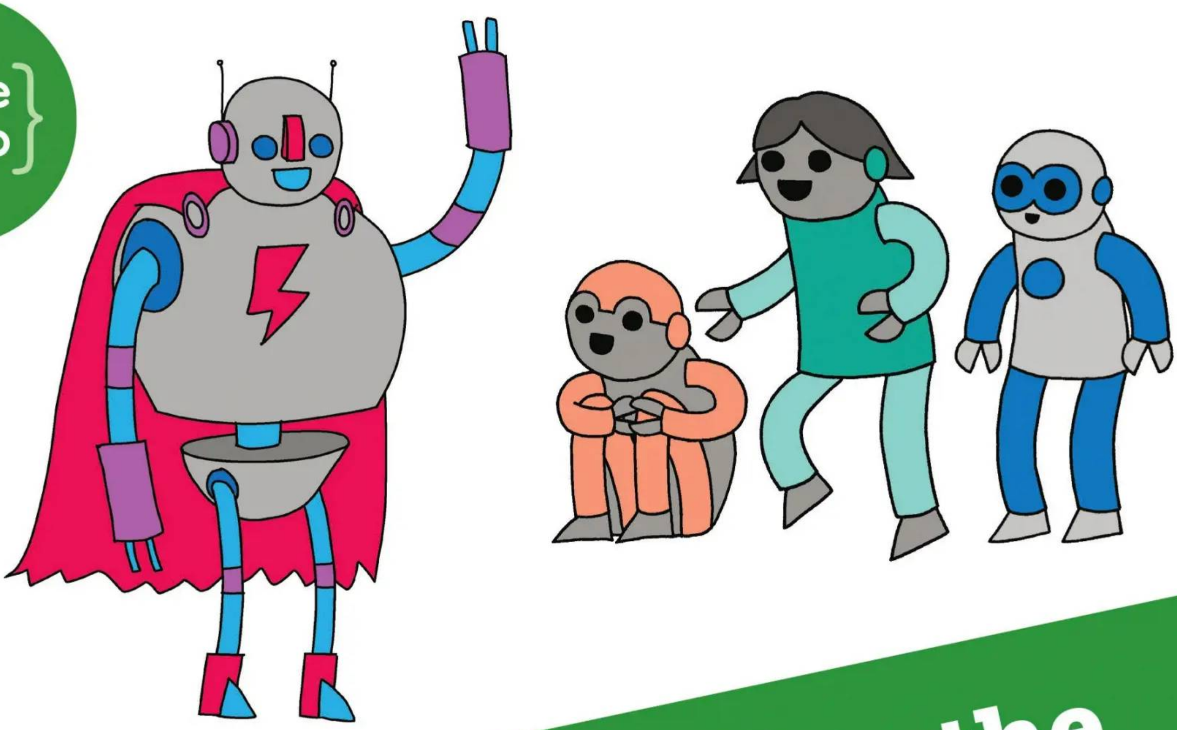
esc-m creates a macro. Arguments to the macro can be inserted using the tab-key.

esc-{ expands the macro with zero or more arguments.

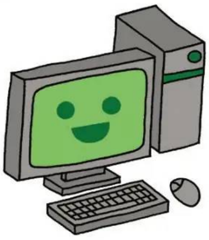
esc-f creates a function.

TeXmacs is an excellent word processor for creating technical or mathematical documentation.

Like *LaTeX, TeXmacs* has built-in document styles – such as letter, article and seminar – to ensure your documents have a consistent and professional look. The real power of *TeXmacs* lies in its tools for inserting formulae and equations, and for creating and editing tables. Then there's a range of mathematical symbols and functions for inserting, numbering and formatting common structures like definitions, lemmas and theorems. Add to that the features for creating and managing bibliographies, tables of contents and lists of figures, and you have a package that is far more adept at handling technical documents than your average word processor. LXF



Can you help inspire the next generation of coders?



Code Club is a nationwide network of volunteer-led after school clubs for children aged 9-11.

We're always looking for people with coding skills to volunteer to run a club at their local primary school, library or community centre for an hour a week.

You can team up with colleagues, a teacher will be there to support you and we provide all the materials you'll need to help get children excited about digital making.

There are loads of ways to get involved!

So to find out more, join us at **www.codeclub.org.uk**

3Jw8GGqdiRsHphOFjEgfZw==

PICO-8

Credit: www.lexaloffle.com/pico-8.php

Coding for a retro pixel fantasy console

Nate Drake is in Pixel Town, as he shows you how to code a retro classic-style 8-bit game on the PICO-8 fantasy console.

OUR EXPERT

Nate Drake is a technology journalist specialising in cybersecurity and retro tech. His first foray into 8-bit gaming was *Space Invaders* at his father's local. He hasn't looked back since!

QUICK TIP

If you can't afford to pay for PICO-8 or just don't want to, you can access PICO-8 Education Edition free of charge at **www.pico-8-edu.com**. This is a free web-based version of the console, which we used to put together this tutorial.

PICO-8, released in 2015, pays homage to the golden pixel era of games. It's a fantasy video game console designed to mimic classic 8-bit systems in a Lua-based environment. The interface not only accepts code but can also be used to design sprites and sound effects. In this guide, we'll cover how to set up *PICO-8,* as well as how to design a rudimentary game with collision detection and scoring.

Fire up your browser and head to **www.lexaloffle.com/pico-8.php**. From here, select the pink button to go to the product page for the most recent release.

From here, choose Get PICO-8. It's currently priced at $14.99. Ignore this and the *Picotron* fantasy workstation for now. Enter your email address in the corresponding field, then choose to pay using either card (via Stripe) or PayPal, but we used the free Education Edition for this tutorial (*see Top Tip left*).

Before diving into scripting language, it's helpful to see what *PICO-8* can do. Fortunately, the console comes with some demo games. To deploy these, run:

```
INSTALL_DEMOS
```

PICO-8 commands operate exclusively in upper case. Once the demos are installed, you'll see them in a list. You can switch into the corresponding directory in exactly the same way as from the Linux terminal:

```
CD DEMOS
```

Next, load the example game *Jelpi* with:

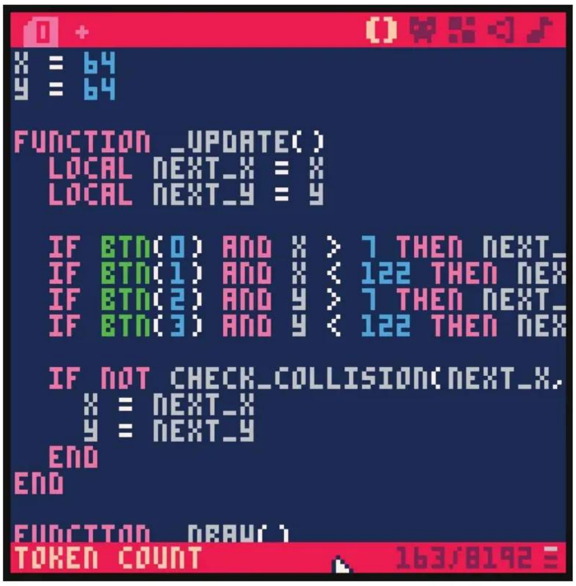
```
LOAD JELPI
```

You can now launch the game by entering `RUN`. This is a charming example of a 2D platformer. You can move the eponymous character around using the arrow keys. Press Z to jump and X to perform a power charge to remove blocks and enemies.

Once you've played the game to your heart's content, press Escape to return to the console. Enter the command `CLS` to clear the game from the screen.

Your first cartridge

Type `REBOOT` into the *PICO-8* console to start a new cartridge. Next, press the Escape key once again to launch the code editor.



```
X = 64
Y = 64

FUNCTION _UPDATE()
  LOCAL NEXT_X = X
  LOCAL NEXT_Y = Y

  IF BTN(0) AND X > 7 THEN NEXT_
  IF BTN(1) AND X < 122 THEN NEX
  IF BTN(2) AND Y > 7 THEN NEXT_
  IF BTN(3) AND Y < 122 THEN NEX

  IF NOT CHECK_COLLISION(NEXT_X,
    X = NEXT_X
    Y = NEXT_Y
  END
END

FUNCTION _DRAW()
TOKEN COUNT                163/8192
```

PICO-8 uses an implementation of the Lua scripting language to create games. It's simple to understand but contains powerful features.

PICO-8 uses a subset of Lua as its scripting language, which has similarities with simple programming languages such as BBC Basic. By way of example, enter the following into the code editor:

```
PRINT("HELLO WORLD")
```

Press Escape to exit the code editor, then enter `RUN` to launch the code. You'll now see the text `HELLO WORLD` appear in the console.

Take this opportunity to save your new program:

```
SAVE HW
```

If you're using the web-based version of *PICO-8,* this automatically downloads a save file in P8 format. This includes data such as the source code, sprites, map, sound effects, music data and an optional label image for cartridges.

You can load existing cartridges in the console's memory via `LOAD` – for example:

```
LOAD HW
```

If you have an existing cartridge file, you can also load it by dragging and dropping it into the *PICO-8* window.

Other filesystem commands are almost identical to those used by the Linux terminal. For instance, to create a folder named **HELLO-WORLD** to store your sample script, run:

```
MKDIR HELLO-WORLD
```

You can then switch into this using `CD` as outlined above, then save your new code there.

Adding interaction

So far, you've learned to create a simple Hello World script, then save it until needed. Next, it's time to create a script capable of interacting with the user. First, repeat the steps above to reboot the console and launch the code editor by pressing Escape. Next, enter the following:

```
X = 64  Y = 64
FUNCTION _UPDATE()
 IF (BTN(0)) THEN X=X-1 END
 IF (BTN(1)) THEN X=X+1 END
 IF (BTN(2)) THEN Y=Y-1 END
 IF (BTN(3)) THEN Y=Y+1 END
END
FUNCTION _DRAW()
 CLS(5)
 CIRCFILL(X,Y,7,14)
END
```

Press Escape to exit the code editor and save your new script with a meaningful name:

```
SAVE CIRCLE
```

You can now run the code. As you'll see, this displays a pink circle on a grey background. You can use the arrow keys to move it around.

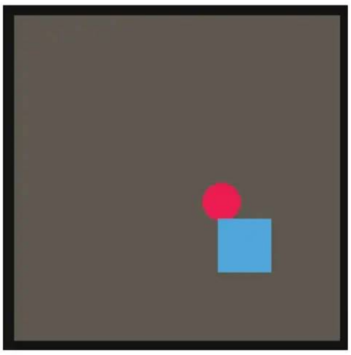
The script does this through using two special callback functions: **_UPDATE** and **_DRAW**.

The **_UPDATE** function simply checks which keys have been pressed. **BTN** returns a value if a button is currently being pressed. The *PICO-8* console defaults to assigning the left, right, up and down arrow keys respectively values 0-3.

When a key is pressed, it alters the values for X and Y, which can then be harnessed by the **FUNCTION_DRAW** to clear the screen (via **CLS**), then use **CIRCFILL** to draw a filled in circle shape at the corresponding X and Y coordinates.

The remaining two values (in this case 7 and 14) correspond to the radius and colour of the circle. Feel free to edit these as you see fit. For instance, changing the final value to 8 will make the circle red.

The start of the code declares values for both X and Y (64). This simply ensures that by default the circle appears at the centre of the screen.



Collision detection prevents objects from overlapping others. It can also be used to trigger events, like picking up an object.

Drawing boundaries

If you took the time to run the example **CIRCLE** script, you'll notice that if you keep moving the shape in any direction it eventually moves off the screen.

If you're designing a video game, you will want to trigger some kind of event when the player-controlled character reaches the edge of the screen.

In the case of this script, let's assume that all the action takes place upon one screen, so that the circle should stop moving once it reaches one of the far edges.

As we know the default coordinates for X and Y (64), it's logical to assume that the screen dimensions are 128x128. This means we can use a crafty **AND** statement in the **_UPDATE** function to ensure that the circle can't be moved off screen – for example:

```
 IF (BTN(0)) AND (X>7) THEN X=X-1 END
```

The value 7 here for X reflects the current radius of the circle. If you're working with a different-sized

» HIDDEN COLOURS

The default colour palette in *PICO-8* gives players the choice between 0 and 15 colours. If you used the sprite editor during this tutorial, you'll have seen these arranged neatly in a grid. You can find a list of the 16 official *PICO-8* system colours at **https://pico-8.fandom.com/wiki/Palette**. Officially, only 16 colours can be used at once, but skilled coders have noted that there are 16 extra undocumented colours. They can be accessed via the palette swapping function in the format:

```
PAL( current color, new color, 1 )
```

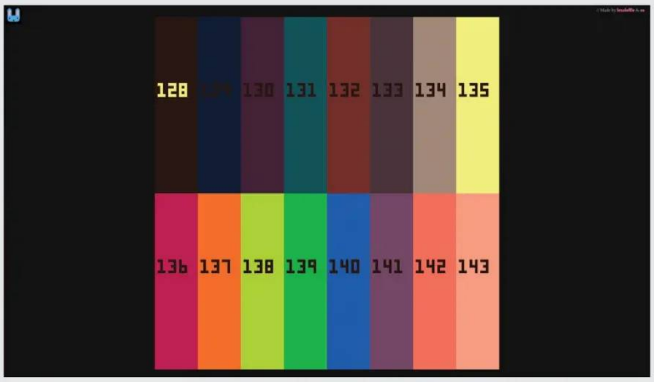
For example, to change the system colour 0 (black) to a rather fetching shade of mauve (141), enter:

```
PAL( 0,141,1 )
```

Readers who have played games coded in Basic may remember the POKE command, which can be used to modify memory addresses. This was used to good effect back in the day to cheat – for example, to change the number of lives a player has left. You can also use this command in *PICO-8* to good effect to enable the hidden colour palette:

```
POKE( 0x5f2e,1 )
```

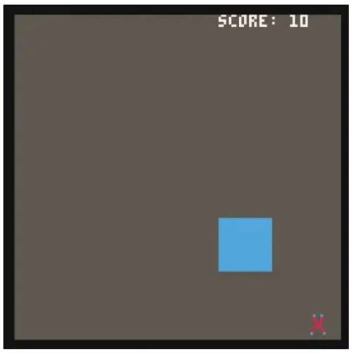
To have the palette swap out all the regular system colours for the hidden ones, enter:



Although PICO-8's hidden colours are undocumented and officially not supported, they work perfectly well in place of system colours.

```
pal( {[0]=128,129,130,131,132,133,134,135,136,137,138,139,140,141,1
42,143},1 )
```

You can download an example script where this code has been deployed to display the hidden palette from **https://bit.ly/lxf329pal**.



Initialise variables such as score at the start of the code, then alter them with in-game events, such as collecting an object.

shape, however, you can adjust this as necessary.

In the case of the Y coordinates, we can also set an upper limit to ensure the circle doesn't disappear off screen – for example:

```
IF (BTN(3)) AND (Y<121) THEN Y=Y+1
END
```

You can download a sample **CIRCLE** script with the screen edges marked as boundaries from **https://bit.ly/lxf329circle2**.

Basic collision detection

While modifying the script in this way clearly marks the game's boundaries, it's not a practical way to create in-game obstacles. To get started with this, add a new function to your script to draw another object:

```
FUNCTION _DRAWBLOCKS()
 RECTFILL(80,80,100,100,12)
END
```

In this case, the new function draws a blue square on screen. The first four values indicate the X and Y values for the corners of the shape. This enables you to draw a rectangle of any size – or in this case, a square. The final value determines its colour.

You can invoke this function from within **_DRAW** by adding the following line before the **END** statement:

```
_DRAWBLOCKS()
```

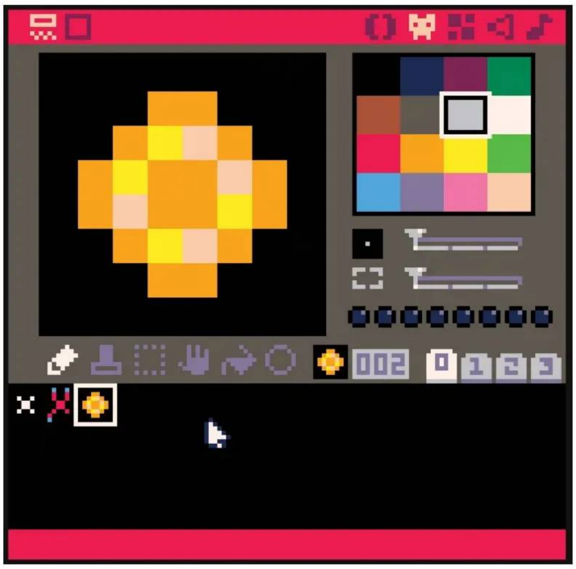
If you choose to run the script at this stage, the blue square appears, but the circle simply moves behind it.

You can fix this by introducing a dedicated function for collision detection – for example:

```
FUNCTION CHECK_COLLISION(CX, CY)
  LOCAL RECT_X1 = 80
  LOCAL RECT_Y1 = 80
  LOCAL RECT_X2 = 100
  LOCAL RECT_Y2 = 100
  LOCAL R = 7
  LOCAL CLOSEST_X = MID(RECT_X1, CX, RECT_X2)
  LOCAL CLOSEST_Y = MID(RECT_Y1, CY, RECT_Y2)
  LOCAL DISTANCE = SQRT((CX - CLOSEST_X)^2 + (CY - CLOSEST_Y)^2)
  RETURN DISTANCE < R
END
```

QUICK TIP

PICO-8's code editor is very flexible. You can use Ctrl+A to select text, as well as Ctrl+V to paste code from the clipboard. If you have downloaded any of the sample files from GitHub, you can also drag and drop them into the console window.



The code editor has a dedicated section for drawing your own sprites. You can also import sprites from external editors.

In this case the function uses local variables to define the values for both the circle's radius and the rectangle's four corners. The **CLOSEST_X** and **CLOSEST_Y** functions are designed to detect the closest points on the rectangle relative to the circle.

The value **DISTANCE** reflects the distance between the circle's centre and this closest point. If the distance is less than or equal to the circle's radius, a collision has occurred.

The **_UPDATE** function can now be updated to perform collision detection to check if the two shapes intersect, then prevent the circle from moving into the square if so:

```
IF NOT CHECK_COLLISION(NEW_X, NEW_Y) THEN
  X = NEW_X
  Y = NEW_Y
END
```

As you'll see from this snippet, the overhauled function needs to make use of new local variables **NEW_X** and **NEW_Y**. You can download a sample of this script with both the modified **_UPDATE** function and new **CHECK_COLLISION** function from **https://bit.ly/lxf329circle3**.

Select your sprites

As any retro gamer knows, sprites are 2D images that can be superimposed on to a gaming background. Typically they're used for moving elements in 2D games. Technically, the red circle in the current *PICO-8* script counts as a sprite but it's not particularly inspiring.

Fortunately, *PICO-8* has a built-in sprite editor that you can use to add slightly more sophisticated graphics. You can access it by clicking the second icon (in the shape of a space invader) in the top-right row of the screen.

Take some time to hover over each of the tools available here. The main ones of interest are the draw tool (pencil icon) and the colour palette. You can use this to draw your own sprites.

If you look in the black pane at the bottom of the editor, you'll see that a sprite has already been drawn for you. Click into this if you like. You can also click just to the right of the symbol to begin drawing a sprite of your own.

Once you've done this, it's time to learn how to invoke it in the game code. *PICO-8* numbers sprites. Excluding the default one already available in the sprite editor, this means your new sprite is now designated as **sprite 1**.

You can then invoke it using the **SPR** command. For instance, to make the **sprite 1** appear in the centre of the screen, return to the game code and enter:

```
SPR(1, 64, 64)
```

Now that you understand how to load sprites, press Escape to return to the code editor. Erase the code you just wrote and paste in the **CIRCLE3** script from the previous section. You can now swap out the plain red circle for your new sprite by updating this line in the **_DRAW** function from:

```
CIRCFILL(x, y, 7, 8)
```

To:

```
SPR(1,x, y)
```

You should note that **SPR** doesn't use the same parameters as **CIRCFILL** because the size and colour(s) of a sprite have already been determined by the editor.

You can download a sample of this script with the red circle replaced by a basic sprite from **https://bit.ly/lxf329circle4**.

You can also use sprites to generate non-player characters (NPCs) and in-game objects. For instance, imagine a game where the player has to collect items to score points.

First, open the sprite editor and click to the right of **sprite 1** in the bottom pane to create a new sprite in the shape of an object of your choice, such as a golden coin, for instance.

Next, add a new line to the **_DRAWBLOCKS** function to place your new sprite at the bottom right-hand corner of the screen:

```
SPR(2,120,120)
```

If you run the code at this stage, the object appears but when you move your character over it, nothing happens. Most in-game objects disappear when the player moves over them, so you can modify your script accordingly. Firstly, create a new variable for whether the object is visible or not at the top of your script – for example:

```
coin_visible = true
```

Next, add the necessary code to the **_CHECK_COLLISION** function to determine whether the **sprite 1** object has intersected with **sprite 2**:

```
IF COIN_VISIBLE THEN
 LOCAL S2_X = 120
 LOCAL S2_Y = 120
 LOCAL S2_SIZE = 8
 IF CX + R > S2_X AND CX - R < S2_X + S2_SIZE AND
   CY + R > S2_Y AND CY - R < S2_Y + S2_SIZE THEN
  COIN_VISIBLE = FALSE
 END
END
```

This code makes use of local variables to plot the location of **sprite 2** and determine if it's intersected with the **CX** and **CY** coordinates of the player. Finally, we can modify the **_DRAWBLOCKS** function to make the coin appear:

```
IF COIN_VISIBLE THEN
  SPR(2, 120, 120)
 END
```

You can find a working version of this script with the above modifications to make the **sprite 2** object disappear when it collides with **sprite 1** from **https://bit.ly/lxf329circle5**.

Keeping score

While the **sprite 2** object currently disappears when the **sprite 1** object moves over it, nothing else happens. Usually games adopt a scoring system so the player can keep track of the game's progress. We can do the same in our script by initialising a dedicated variable – for example:

```
SCORE = 0
```

Next, we need a way to change the score. Let's imagine that the player gets 10 points each time they pick up the **sprite 2** object. In this case you can add a dedicated line to the corresponding section of the **_CHECK_COLLISION** function:

```
SCORE += 10
```

Finally, we can modify the **_DRAW** function to display the current score at the top of the screen just after the line where **_DRAWBLOCKS** is invoked:

```
PRINT("SCORE: "..score, 80, 0, 7)
```

In this case, the values 80 and 0 represent the X and Y coordinates of where the score text will be printed. The value 7 represents the colour white.

You can download a sample script with the above modifications for a basic scoring system from **https://bit.ly/lxf329circle6**.

Although we've covered the basics here of moving a character around the screen and collecting objects, you still have some way to go to code a fully-fledged game. We recommend going through the official manual to take your title further – you can view it at **https://bit.ly/lxf329man**. LXF

QUICK TIP

If you're using the desktop version of *PICO-8*, you can import sprites created using an external editor like *Aseprite*. Images must be 128x128 pixels and use colour supported by *PICO-8*. Enter the command `FOLDER()`. Paste your sprites here so they can be accessed by the game.

SOUND EFFECTS

Sound effects in *PICO-8* can be managed via the *SFX* command, which can play an effect on any one of the fantasy console's four sound channels. It exists as a sequence of tones or notes, and is written in the format:

```
sfx( n, [channel,] [offset,] [length] )
```

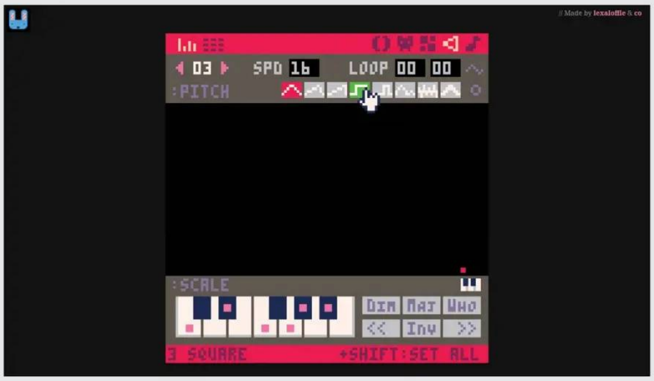
So for example:

```
SFX(3, -1, 21, 6)
```

In this case, **n** denotes the number of the sound effects to play from 0 to 63. These are preconfigured but you can edit them via the code editor by clicking on the corresponding icon at the top-right of the screen.

From here, you can click on the pink arrows at the top-left to cycle through different effects. Click the keyboard icon to see the sound represented visually. You can also alter the speed via *SPD* and choose a different wave for the pitch.

The **offset** value in *SFX* determines the note position (0-31) in the sound effect to start playing. By default, *PICO-8* plays sound effects from the start. The **length** determines the number of notes in the sound effect to play (0-31). By default, the console plays all of them, so you don't need to specify this unless you want specific notes. If the game is playing music via the `MUSIC()` function, *SFX* does its best not to interfere with any sound channels being used by checking its channel mask, unless you configure it to use the same channel.



PICO-8 contains 64 preconfigured sound effects. You can modify aspects of these, such as channel and duration, via the code editor.

RUST

Part Five! Complete your collection. Back issues page 64!

Runing Rust on the Raspberry Pi

David Bolton continues looking at Rust development with SDL2 but now he's doing it on a Raspberry Pi of all places!

OUR EXPERT

David Bolton has been writing code for Raspberry Pis for over 10 years and now he's doing it with Rust, both developing and running on his new Raspberry Pi 5.

Previously on coding in Rust… We created a program *PokerHand* that read in a text file of cards and evaluated each line to figure out the best poker hand. Out of curiosity, we subsequently modified the program so that it no longer used HashMap and HashSet, guessing that maybe those had too much overhead for a small numbers of cards. The HashMap version took 550ns per hand on Ubuntu running in a VM. Without HashMap/HashSet, the time dropped to 125ns, an amazing speed-up of over four times. We put the project files zipped up on GitHub (**https://bit.ly/lxf329git**). On the Raspberry Pi 5, the time was 175ns per hand.

Measuring the temperature of a Pi

While it's less important in a Raspberry Pi 3B/4B, the Pi 5 tends to run a bit on the warm side, and if you haven't got any active cooling, you need to keep an eye on the temperature. You can do this manually from a terminal with this command:

```
$ vcgencmd measure_temp
```

This outputs something like:

```
temp=48.3'C
```

But in a program, it just takes this five-line function that returns an f32, the equivalent of a float in C/C++:

```
fn get_temperature()-> f32 {
  let mut file = File::open("/sys/class/thermal/thermal_
zone0/temp").unwrap();
  let mut contents = String::new();
  file.read_to_string(&mut contents).unwrap();
  let temp: f32 = contents.trim().parse().unwrap();
  temp / 1000.0
}
```

Now, if you run that on anything that isn't a Raspberry Pi, your program will panic. So, before you can call it, check it's running on a Raspberry Pi with this function, which returns true if it is:

```
fn is_pi_system() -> bool {
  let info = uname().unwrap();
  if info.nodename!="raspberrypi" {
    return false;
  }
  if info.machine!="aarch64"{
    return false;
    }
  true
}
```

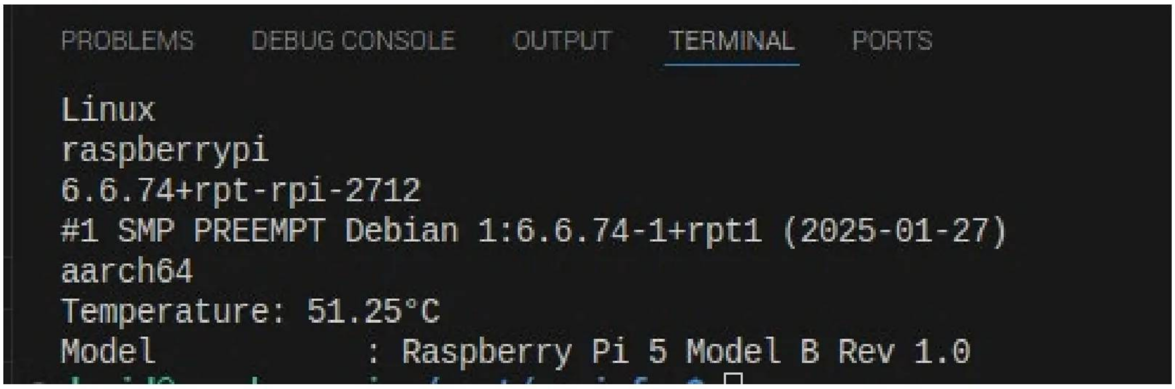
Before you can compile this, you need to add the uname crate to the project with this:

```
$ cargo add uname
```

This crate is just a wrapper around a call to libc.uname. If you find the uname crate on **Crates.io**, it includes a link to the GitHub source (**https://bit.ly/lxf329crate**), useful if you're curious to see how it works The function **uname()** returns a struct with five fields in it. We check two of these: the nodename and

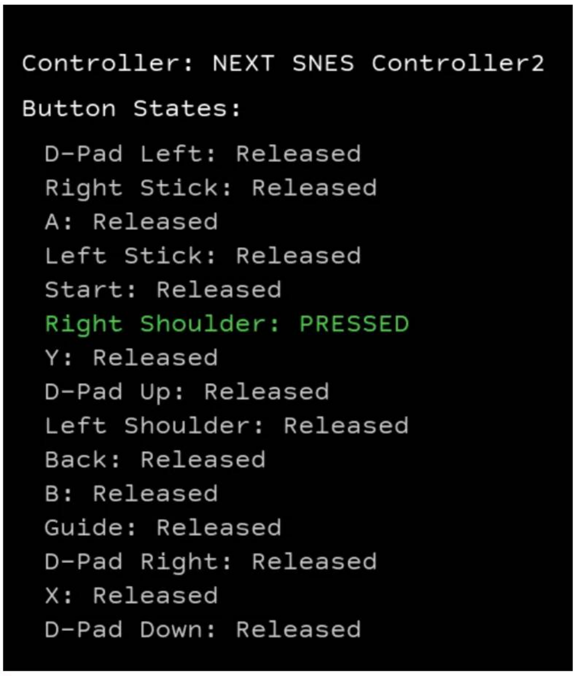
QUICK TIP

To take screenshots on a Pi, you should use *Grim*. This is because Raspberry Pi OS uses Wayland for the display and several screen-grab utilities, such as *Scrot*, don't work with it.



```
Linux
raspberrypi
6.6.74+rpt-rpi-2712
#1 SMP PREEMPT Debian 1:6.6.74-1+rpt1 (2025-01-27)
aarch64
Temperature: 51.25°C
Model           : Raspberry Pi 5 Model B Rev 1.0
```

Running Sysinfo on a Raspberry Pi 5.



```
Controller: NEXT SNES Controller2
Button States:
  D-Pad Left: Released
  Right Stick: Released
  A: Released
  Left Stick: Released
  Start: Released
  Right Shoulder: PRESSED
  Y: Released
  D-Pad Up: Released
  Left Shoulder: Released
  Back: Released
  B: Released
  Guide: Released
  D-Pad Right: Released
  X: Released
  D-Pad Down: Released
```

Output of program controller when right shoulder button is pressed.

A typical gamepad controller.

the underlying architecture machine. While you might get away with just checking the nodename, if you run it on Raspberry Pi OS running on a virtual machine, the **get_temperature()** function won't work.

The entire project is on GitHub and is called *Sysinfo* (**https://bit.ly/lxf329sysinfo**). When you compile and run it on a Pi, you'll get something like the screenshot *(opposite page)*. The last line shows what model it is and comes from doing the code equivalent of:

```
$ cat /proc/cpuinfo
```

That produces over 35 lines of text – give it a try – but *Sysinfo* just outputs the one line with the word Model in it.

Reading a gamepad

It's handy if you have a joystick or gamepad plugged in to a USB port but there is no standard layout. Once you have created a config string with *ControllerMap (see boxout, p.96)*, it takes just a few lines to read it in. Ours is called **gamepad.txt** and it's in the project folder:

```
  // Set up controller mapping if provided
  let controller_mapping = read_file_to_
string("gamepad.txt").expect("Failed to load gamepad.
txt");
  if controller_mapping.len() >0 {
     let _= sdl_context.game_controller()?.add_
mapping(&controller_mapping).expect("Mapping
failed to add");
  }
```

So, plug in your gamepad. Run *ControllerMap* and generate a **gamepad.txt**, then compile and run the controller (**https://bit.ly/lxf329control**) program to verify that all the buttons are recognised correctly. Note you must have the **gamepad.txt** file in the same location as the controller executable when you run it.

The controller program

This program displays the buttons and shows any that are pressed in green with the word 'Pressed'. For some reason, *ControllerMap* seems to get our gamepad buttons the wrong way round. It shows A when B is pressed and Y when X and vice versa. It was easily fixed by changing this part of the text file containing the map: `From a:b2,b:b1,x:b3,y:b0 to a:b1,b:b2,x:b0,y:b3`.

The CardDraw program

This program (**https://github.com/David-H-Bolton/Projects/blob/main/rust_carddraw.zip**) uses SDL2 to display five playing cards picked randomly on screen and also shows the temperature and the time to draw a frame. It's the base for any programs that need to display cards. Just for a bit of fun, it also displays two rows of 15 cards reduced to quarter size.

It doesn't do much different from the *Choice* program last month. The playing cards came from Wikipedia and were created by David Bellot. They're in

QUICK TIP

If you don't have a Raspberry Pi but want to try developing for it and have a PC or Mac available, download the VM from https://bit.ly/lxf329pivm.

» RUST ON A RASPBERRY PI

There's no reason why you wouldn't want to develop Rust programs on a Pi. The only issue might be if you were running it on a 3B or earlier model, which might struggle. It was tested on a Raspberry 5 with 8GB of RAM. It should also be possible on a 4B as well, just slightly slower.

The things that make a Pi different from other Linux boxes are having an ARM CPU, and Pi-specific things such as temperature sensors. Plus, we can plug in a gamepad and use it in games or other apps. We need to use SDL2 for that because it comes very well equipped to work with any gamepad in existence.

The Raspberry Pi 5 can get hot if not actively cooled, so being able to display the temperature within an application can also be quite handy. To check that your app is running on a Raspberry Pi, do this from the command line with the *uname* command. Run this command in a terminal: `$ uname -a`.

There are other parameters that give individual parts but **-a** (for all) lists everything. There's a Rust crate called uname and we'll use that so our programs can figure out if they are running on a Raspberry Pi and only check for Pi-specific features in that case.

»

» GAME CONTROLLERS AND SDL

Previously when you installed libsdl2-dev, it installed test software that included a program called *ControllerMap,* which enables you to configure your game controller/joystick/joypad/gamepad and so on. The C source is still available but now you have to compile it yourself. David has written instructions for doing this at **https://bit.ly/LXF329ControllerMap** and it's not too difficult.

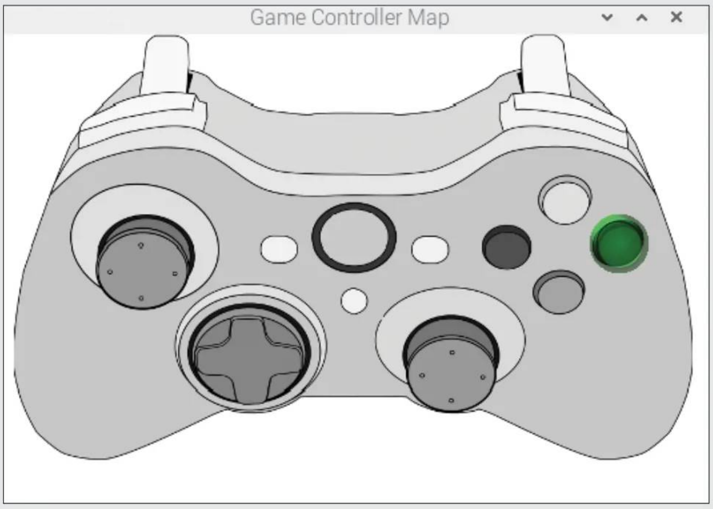
Once it's installed, you run it and it cycles through the on-screen controls one button at a time. You press the button corresponding to the green on-screen button (press the space bar to skip buttons that don't exist), and at the end it outputs a configuration string. A typical config string looks like this:

```
03000000100800000 1e5000010010000,usb gamepad,platform:Linu
x,crc:417e,a:b2,b:b1,x:b3,y:b0,back:b8,start:b9,leftshoulder:b4,rightsh
oulder:b5,leftx:a0,lefty:a1,
```

This has to be either hard-coded into the program, or loaded from an external file. If you want your program instead to work with any known game controller, there is a GitHub site (**https://bit.ly/lxf329game**) that provides a file holding a vast number of these game controller strings. The current version is 2,121 lines long! The SDL2 library includes a C function that can load this file and it's also in the file **controllers.rs** in the SDL2 crate:

```
SDL_GameControllerAddMappingsFromFile("gamecontrollerdb.
txt");
```

Curiously, we found that it got our gamepad buttons mixed up. When clicking an A-button, it thought it was B and vice versa. The same was true for the X and Y buttons. We edited the config string manually, swapping them, and that fixed it.



The screen display for ControllerMap.

QUICK TIP

When benchmarking your app, you can have *Hyperfine* generate a Markdown file of the results from a run if you add `—export-markdown file` to the command

SVG format which is XML. There are crates available for handling SVG files, but time was a little short, so we viewed the cards in a browser, took a screenshot and saved it as a PNG, then removed the bottom row, leaving four rows of 13 playing cards. It displays five cards on screen, along with the temperature and time taken to draw a frame, which is between 65 and 80 microseconds. Pressing the space bar changes the cards displayed.

The consts **CARD_X_OFFSET**, **CARD_Y_OFFSET**, **CARD_SPACING_X** and **CARD_SPACING_Y** are all 0, but had non-zero values when we were experimenting with other card sheet files. Also, if the layouts aren't arranged as four rows of 13 cards, you need to alter the code in the two **for** loops that get the **src_x** and **src_y** of the top-left of each card.

When running on a Raspberry Pi, rather than reading the temperature 60 times per second, a counter counts up to 60, then resets and reads the temperature once per second, and writes it into a string variable along with the elapsed time for this frame. This cached string is displayed on each frame but only gets updated once per second. If it updated every frame, it would be very hard to read.

If the temperature of the Pi rises above a danger threshold temperature, then the temperature string starts flashing. A bool flag **show_flash** is toggled three times a second – this is done by checking the counter that increments each frame. When it reaches a multiple of 20 (using the operator **%**), **show_flash** is toggled. Just before displaying the temperature, if the temperature is below the danger threshold, the **show_flash** flag is forced to true, so there's no flashing in that case. Alter the const **DANGER_TEMPERATURE** to 40 and recompile to see what it looks like flashing.

You might be wondering why the temperature string **temp_str** is cleared then the new temperature is appended. That's because it's defined as a string not an &str. If it was an &str, you could assign the new temperature. It is defined earlier in line 104:

```
let mut temp_str=String::from("");
```

If it was declared as:

```
Let mut temp_str = "";
```

Then it would be an &str. Unfortunately, if it's an &str, as soon as you try to display it after the `if counter == 60` block, the compiler gets antsy with a temporary value dropped while borrowed compile error. This is the Rust borrow checker doing its thing.

Keen eyes might wonder why the timing output is spread over two lines – 167-168. This is because the string conversion for Duration introduces a rubbish character for microseconds instead of µ. Previously, we'd used the println! macro to output the time, as in the line below:

```
println!("Time per hand: {:?}",duration / 1000);
```

For SDL2, we have to convert the duration into a string so it can be printed out, and we used the format! macro. But calling this macro with the same string **{:?}** does not work exactly as it did in println!. So, for plan B, we got the time in nanoseconds, then divided it by 1,000 to get the microsecond time. We'd previously run it with println! to see what timescale it should be and then hard-coded the µ character:

```
temp_str.push_str(format!("{:?} us",time.as_
nanos()/1000u128).as_str());
```

Rust lacks ?: but...

In C, you can use a conditional, aka ternary, operator to assign value a if something is true or value b if not. `c = a ? b : d;` assigns b to c if a is non-zero, otherwise it assigns d.

Rust doesn't have this but has block expressions, where the last value in a block (by itself and without a semi-colon) is returned. And Rust treats an **if** statement as an expression so it can be assigned to a variable, as can be seen in line 153 of *CardDraw:*

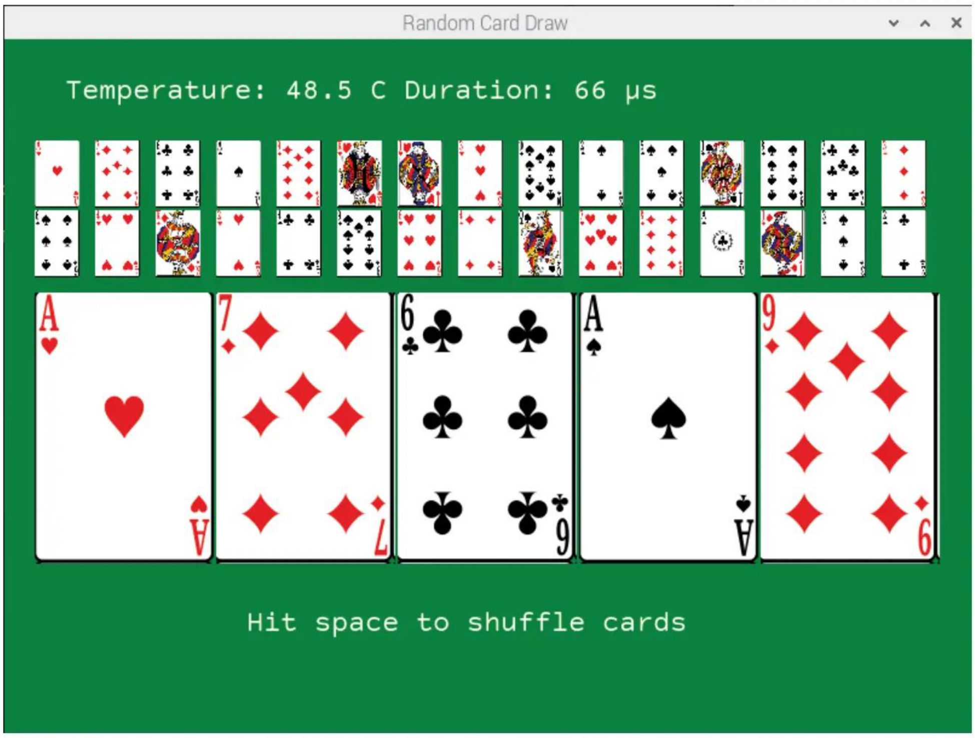
```
let dest_y = if index<15 {80} else {135};
```

This sets the **dest_y** of cards indexed 14 or below on line 80 and 15 and above on line 135. This is an example of idiomatic Rust or Rusty code.

Benchmarking PokerHand

It can be useful to have a more accurate measurement of how long it takes to run a program. Using the faster version of *PokerHand* mentioned at the start, we decided to benchmark it on the Raspberry Pi 5. Running it once from the command line gave an average time of around 175ns per hand.

But there's always a bit of overhead when you run programs that way. There's the OS in the background and the latency of the drive (ours was an SD card), plus sometimes programs need to warm up. Also, 1,000 hands might not be enough, so first we generated a file holding a million hands, then we modified *PokerHand* to use a million. Running it gave an average time of 176ns, so it's consistent between 1,000 and a million hands. The project for *PokerGen* – the program that generates the file of cards – is on GitHub (**https://bit.ly/lxf329poker**).



```
Temperature: 48.5 C Duration: 66 µs
```

```
Hit space to shuffle cards
```

The CardDraw program running on a Raspberry Pi.

To benchmark it, we installed *Hyperfine* (**https://github.com/sharkdp/hyperfine**), an open source benchmarking program written in Rust by German developer David Peter. You can install it on Raspberry Pi OS (which is based on Debian Bookworm) with either of the following two commands:

```
$ sudo apt install hyperfine
$ cargo install –locked hyperfine
```

After that, running *Hyperfine* is just a matter of switching the terminal into the **target/release** folder, copying the card files in there, then running the following command:

```
$ hyperfine —shell=none —warmup 3 './pokerhand 1000_card_hands.txt'
```

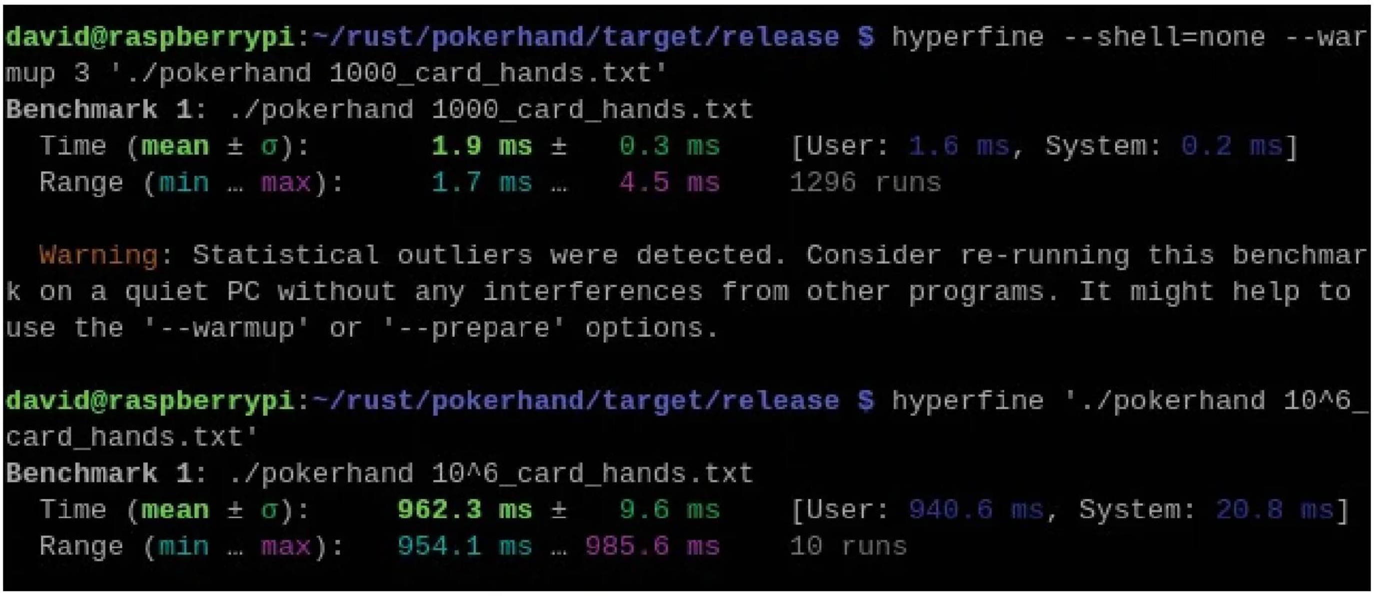
The **shell=none** is needed when running the benchmark with 1,000 cards as it's too quick to measure and this compensates for the OS shell startup. It's not needed for the million-card file.

The **--warmup 3** has it do three runs to warm up memory allocations before the main benchmark. If you run it without this, it points out that the first run took longer than the rest and recommends you include it.

The runs provide a range of times for 1,000 cards of 1.9ms +/- 0.3ms. But it did report that some outlier results were detected even when run with **--warmup**. The second row shows a worst case of 4.5ms compared to a best case of 1.7ms. To ensure it runs for at least three seconds, *Hyperfine* runs the program as often as it deems necessary: 1,296 times for the 1,000-card file and 10 for the million-card file.

QUICK TIP

Another way to identify the model of your Raspberry Pi is the terminal command *pinout*. The first line of the output is the Description field, which lists the model.



```
david@raspberrypi:~/rust/pokerhand/target/release $ hyperfine --shell=none --war
mup 3 './pokerhand 1000_card_hands.txt'
Benchmark 1: ./pokerhand 1000_card_hands.txt
  Time (mean ± σ):       1.9 ms ±   0.3 ms    [User: 1.6 ms, System: 0.2 ms]
  Range (min … max):     1.7 ms …   4.5 ms    1296 runs

  Warning: Statistical outliers were detected. Consider re-running this benchmar
k on a quiet PC without any interferences from other programs. It might help to
use the '--warmup' or '--prepare' options.

david@raspberrypi:~/rust/pokerhand/target/release $ hyperfine './pokerhand 10^6_
card_hands.txt'
Benchmark 1: ./pokerhand 10^6_card_hands.txt
  Time (mean ± σ):     962.3 ms ±   9.6 ms    [User: 940.6 ms, System: 20.8 ms]
  Range (min … max):   954.1 ms … 985.6 ms    10 runs
```

Running Hyperfine on PokerHand with 1,000 and million-card hands.

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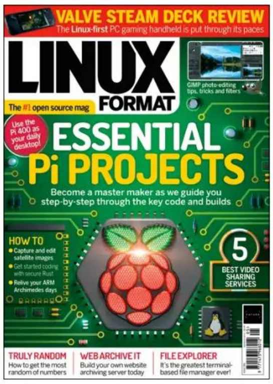
SAVE YOUR OLD PC!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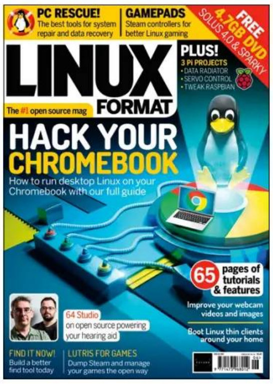
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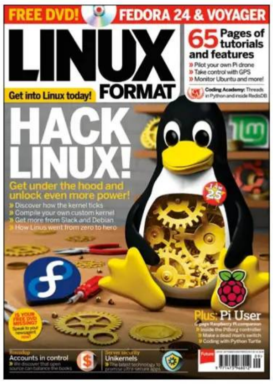
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Bright Days by Ludwig Jacoboowski
Ah, our brilliant days shine like eternal stars,
they glow past as consolation for future sorrow.
Don't cry because it's over! Smile because they have been!
And if the days get cloudier, our stars redeem!

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